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April 12, 2017

VIA ELECTRONIC FILING

Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

Re: ViaSat, Inc., *Ex Parte* Submission, GN Docket No. 14-177; IB Docket Nos. 15-256 & 97-95; RM-11664; WT Docket No. 10-112

Dear Ms. Dortch:

As part of the ongoing *Spectrum Frontiers* proceeding, ViaSat provides the attached Report Summary and Comsearch Report on earth station testing in Carlsbad, California ("Carlsbad Earth Station Testing Report"). The Report analyzes the ability of 28 GHz satellite earth stations to co-exist with terrestrial fixed and mobile services, including 5G/UMFU, in typical roof top mounting scenarios, including in urban and suburban settings.

Specifically, the Carlsbad Earth Station Testing Report consists of measured data in the vicinity of an existing earth station that was deployed well before the release of the *Spectrum Frontiers Order* last summer, and whose location thus was selected without reference to the terms of that Order. The measurements are based on the actual performance of the earth station and on existing site conditions. Consistent with Section 25.136(a)(4) of the Commission's rules, the measurements were conducted to determine the "area in which the earth station generates a power flux density (PFD), at 10 meters above ground level, of greater than or equal to -77.6 dBm/m^2/MHz."

As explained in the Carlsbad Earth Station Testing Report, even without any attempt to mitigate emitted signal levels toward the horizon from this typical commercial roof top site, the measured levels at all but one location, as expected, were below the -77.6 dBm/m^2/MHz threshold level. The one exception involved an exceedance by less than 1 dB at a location with a significant ground elevation above the base of the building on which the earth station is deployed. ViaSat explains that even in this one case, it would be easy to install shielding that would reduce the generated PFD at this location by about 1 dB to below that threshold level.

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In short, this report supports ViaSat's position that the careful design, placement, and installation of 28 GHz earth stations readily would allow their deployment virtually anywhere 5G/UMFU may also deploy, even in urban and suburban environments.

Please contact the undersigned if you have any questions regarding this submission.

Respectfully submitted,

/s/

John P. Janka

Attachment

cc: Jose Albuquerque
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Analysis of 1.8 meter Antenna Measurement Test Results for 27.5 – 28.35 GHz

Introduction

ViaSat has been a consistent proponent of spectrum sharing on reasonable and equitable terms throughout the FCC's Spectrum Frontiers proceeding (*Spectrum Frontiers*).[1] As part of that discussion, ViaSat has provided supporting information about the ability of satellite earth stations to co-exist with future terrestrial fixed and mobile services, including UMFU or 5G. This additional report, combined with independent, third party testing from industry-leading experts using state-of-the-art measurement gear and techniques, further substantiates ViaSat's previous submissions.[2]

Background

ViaSat previously submitted an "Analysis of EIRP density toward the horizon for ViaSat site licensed aggregation and interconnection facilities (AIF)."[3]

That analysis considered three antenna size classes that were representative of the earth stations employed or planned to be employed as AIFs for its three generations of High Capacity Service (HCS) satellites.

Subsequent to submittal of that analysis, ViaSat performed testing around an existing 1.8 m antenna at its Carlsbad, California headquarters and found no detectable signal level above the spectrum analyzer noise floor at each ground level measurement location.[4]

Following release of the *Spectrum Frontiers Order* in July 2016 and the adoption of sharing criteria for protected earth stations of -77.6 dBm/(m^2 * MHz) as measured 10 m above ground level (AGL), ViaSat engaged Comsearch to conduct measurements ("Comsearch Testing") around a 1.8 m antenna at 2 m (ground level) and 10 m AGL (the FCC-specified antenna height for measurement). A report of the Comsearch Testing is attached as Annex 1.

The goal of the testing was twofold. First, to determine whether free space loss conditions alone applied or whether additional losses were present along the azimuths to the various test

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[1] *See, e.g.*, Comments of ViaSat, Inc., Further Notice, GN Docket No. 14-177, et al., at 4 (Sept. 30, 2016); *Use of Spectrum Bands Above 24 GHz for Mobile Radio Services*, Report and Order, 31 FCC Rcd 8014 (2016) ("*Spectrum Frontier Order*").
[2] ViaSat commissioned Comsearch, a national radio frequency expert consultancy. Comsearch engineers average over 15 years of field engineering experience, using state-of-the-art measurement equipment and techniques, with extensive propagation experience. URL: http://comsearch.com/services/site-services/rf-test-measurements/.
[3] ViaSat, Inc., Notice of *Ex Parte* Presentation, GN Docket No. 14-177, *et al*., at Attachment 2 (Apr. 21, 2016) ("ViaSat April 21 *Ex Parte*").
[4] ViaSat, Inc., *Ex Parte* Letter, GN Docket No. 14-177, *et al*., at 8 (July 7, 2016) ("ViaSat July 7 *Ex Parte*").

measurement locations. Second, to determine if the antenna transmitting at the nominal power density of a third generation AIF would meet the expected power flux density (pfd) value at the distance filed in the ViaSat April 21 *Ex Parte*.

Transmitting Antenna Characteristics

While minor performance differences due to different feed configurations can be expected, the 1.8 m antenna in question is representative of the type of 1.8 m antenna to be used for future AIFs for the ViaSat third generation HCS satellites. The antenna is roof mounted on a three-story building with parapet wall of varying height around the roof top. The parapet wall is part of the architectural design of the building and provides visual screening of roof top equipment such as HVAC units and other antennas. The height of the parapet wall varies between one and a half and three feet. In addition to the parapet wall, the roof of the building also includes a recessed area approximately two and half feet deep to further aid in screening roof-top equipment from view.

The 1.8 m antenna is mounted in the roof-top recessed area and aligned to point at the WildBlue-1 satellite at 111.1° W.L. The nominal pointing angles for this spacecraft are 168.8° azimuth and 50.1° elevation.

Because no measureable signal had been detected at ground level during prior testing, the testing with Comsearch was configured to use a CW carrier rather than a modulated carrier to provide a better C/N and increase the likelihood of signal detection at the various measurement locations. To operate the antenna, the testing used a standard ViaSat integrated assembly which incorporates a combined modem and radio frequency transceiver all in one module.

The power into the antenna feed was configured to be 0 dBW (1 W) and verified at the antenna feed port to be -0.4 dBW using calibrated test equipment prior to the start of testing. Comsearch verified that the bursting CW signal being transmitted at the frequency of 28212.5 MHz was readily observable at the roof-top location, inside of the parapet wall, with the spectrum analyzer configured to maximum hold.

Following confirmation of source signal calibration, Comsearch proceeded to make measurements at various locations in the area around the building at both ground level (2 m AGL) and at the FCC reference *Spectrum Frontiers Order* UMFU operational antenna height of 10 m AGL. Photos of the test locations and screen shots of the spectrum analyzer plots can be found in Section 3 of the Comsearch report, and a summary of the resultant signal level measurements are provided in Tables 4.1 and 4.2 in Section 4 of the Comsearch report.

Analysis

There are two parts to the analysis. The first part examines whether a signal was present at a location when Comsearch made their measurement, and if so how the signal compared to the predicted value assuming free space losses alone and whether there were additional losses in the path. The second part uses the measured signal values and other information about the ViaSat AIF to calculate the power flux density associated with each measurement. Both of these analyses are described below.

Signal Presence Measurement and Additional Losses Analysis

Comsearch performed measurements with calibrated test equipment using the industry standard signal substitution method, as recommended by the National Spectrum Management Association (NSMA).[5] The signal value results recorded in Tables 4.1 and 4.2 of the Comsearch report and represent the measured level of the CW carrier transmitted from the 1.8 m antenna system being tested, as reduced by path loss and additional losses between the antenna and measurement location. It should be noted that the recorded values suffixed with NF indicate that no signal was observed above the measurement system's noise floor (i.e., the recorded value was that of the noise floor in that instance). Because a spectrum analyzer functions like any other receiver, its noise floor is affected in the same way by signals (or interference) being received. The increase in the displayed response above the noise floor in dB is calculated as:

$10\ \log_{10}\left(1+10^{\frac{I/N}{10}}\right)$, where I and N are the actual interference and noise levels (1)

For example, if the received signal is equal to the noise floor, the two add in amplitude and the displayed response is twice that of the noise alone and a 3 dB rise above the noise floor is observed. A signal -12.2 dB lower than the noise floor results in a 0.25 dB increase in the displayed value. Given that no visible response was seen on the analyzer, the actual signal value then was likely more than 10 dB below the noise floor[6].

To determine the additional loss, if any, over and above free space path loss in the direction of the measurement location, the EIRP in the direction of the measurement location must first be determined.

To do this, antenna gain in the direction of the measurement location is added to the transmitter power being applied the antenna feed. Tables 4.1 and 4.2 of the Comsearch report contain the azimuths to and from the transmitting antenna, as well as the distance in meters. The Comsearch tables do not, however, reference the bearing along which the antenna is transmitting, nor is the elevation angle of the transmitting antenna included.

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[5] The National Spectrum Management Association (see URL: http://nsma.org/), Recommendation WG 4.88.013 Rev.1

[6] Spectrum Analyzer Noise Measurements, HP Application Note 150-4, 1974; and Spectrum Analyzer Measurements and Noise, Agilent Application Note 1303.

The transmit antenna's bearing and the elevation angle information are needed in order to determine the off-axis angle in azimuth and in elevation in order to determine the estimated off-axis gain discrimination in the direction of the signal measurement site. This information is provided in the Transmitting Antenna Characteristics section above. The operating azimuth angle of the 1.8 m antenna is 168.82° (as referenced to True North at 0°) and the elevation angle is 50.1°.

With this information and the antenna gain patterns, the EIRP density in the direction of the measurement site can be calculated. For example, for measurement Site 1, the azimuth angle from the transmitting antenna toward the measurement site is given as 170.29° in Table 4.1 of the Comsearch report. Subtracting the transmitting antenna's bearing toward WildBlue-1 of 168.82° from 170.29° yields an off-axis angle of 1.47°. By examining the manufacturer's antenna gain patterns, attached as Annex 2,[7] it can be seen that the off-axis gain discrimination in azimuth is 35 dB and the gain discrimination in elevation is 70 dB, so the larger of the two values is used. In reviewing the off-axis angles for each site, it can be seen that for all measurement locations, the larger 70 dB elevation off-axis gain discrimination value applies.

The nominal gain at 28.212.5 GHz is 52.59 dBi and the input power to the antenna is -0.4 dBW, so the EIRP toward the horizon is -0.4 dBW + (52.59 dBi – 70 dB) = -17.81 dBW.

Using the free space path loss (FSL) formula (2), the expected FSL for the 66.14 m distance is calculated in dB as 97.86 dB.

$$10\, log\left(\left[\frac{4\pi d}{\lambda}\right]^2\right) \qquad (2)$$

The expected measurement value is then the EIRP – FSL = -115.67 dBW. The actual measured value recorded for Site 1 in Table 4.1 was -137.51 dBW. The additional loss is then -115.67 dBW minus -137.51 dBW = 21.84 dBW.

The process was repeated for each of the measurement sites and measurement heights (2 m and 10 m) and the results are recorded in Table 1.

[7] Annex 2, General Dynamics Antenna Test Report.

Measurement Location	Measurement Height (m)	Free Space Loss (dB)	Recorded Signal (dBW)		Expected Signal (dBW)	Additional Losses (dB)	
Site 1	10	97.86	-137.51		-115.67		21.84
Site 1	2	97.86	-158.19	NF	-115.67	≫	42.52
Site 2	10	98.30	-149.10		-116.11		32.99
Site 2	2	98.30	-155.56	NF	-116.11	≫	39.45
Site 3	10	103.43	-141.30		-123.24		18.06
Site 3	2	103.43	-159.65	NF	-123.24	≫	36.41
Site 4	10	107.46	-133.25		-125.27		7.98
Site 4	2	107.46	-160.00	NF	-125.27	≫	34.73
Site 5	10	111.46	-140.68		-129.27		11.41
Site 5	2	111.46	-147.78		-129.27		18.51
Site 6	10	112.33	-144.95		-130.14		14.81
Site 6	2	112.33	-154.82		-130.14		24.68
Site 7	10	110.59	-155.96	NF	-128.40	≫	27.56
Site 7	2	110.59	-158.19	NF	-128.40	≫	29.79
Site 8	10	109.03	-158.63	NF	-126.84	≫	31.79
Site 8	2	109.03	-158.63	NF	-126.84	≫	31.79
Site 9	10	111.04	-158.10	NF	-128.85	≫	29.25
Site 9	2	111.04	-159.44	NF	-128.85	≫	30.59
Site 10	10	112.47	-158.60	NF	-130.28	≫	28.32
Site 10	2	112.47	-158.77	NF	-130.28	≫	28.49
Site 11	10	98.87	-157.48	NF	-116.68	≫	40.80
Site 11	2	98.87	-158.78	NF	-116.68	≫	42.10

Table 1 Recorded vs Expected Signals and Additional Losses for Measurement Locations

Examining the results in Table 1 shows that in many cases for the 10 m reference height and for the majority of the 2 m height measurement locations, no signal was observed above the test equipment noise floor. The largest observed signal was at the Site 4 location. The measurement location also had the lowest additional losses above the expected free space loss of 8 dB. This result was anticipated because the terrain at that signal test location is approximately 20 feet above the terrain at the base of the building on which the transmitting antenna is located. Also, from the Comsearch photos it can be seen that the parapet wall on that area of the building where the transmitting antenna is located was at the lowest height and the measuring antenna had a line of sight view to the transmitting antenna. Raising the parapet wall in the direction of the higher terrain would provide additional blockage and increase the losses above the FSL.

Power Flux Density Measurement

The second part of the analysis is to determine the power flux density at each of the measurement locations. To use the Comsearch results meaningfully, the recorded signal level values must first be scaled to a reference bandwidth and converted to a flux density. That is, converted from dBW to dBW/(m^2 * MHz).

While the transmitted power of the unmodulated CW carrier from the 1.8 m antenna is known, to convert the power to a power density that represents the third generation AIF, the modulated bandwidth associated with that power level in normal operation must be known or calculated for use in the density conversion.

In the ViaSat April 16 *Ex Parte*, the antenna input density for the third generation AIF was projected to be -19.0 dBW/MHz. However, since that *ex parte* was filed, ViaSat has further reduced the expected nominal antenna input power density for this class AIF to -24.3 dBW/MHz.

The equivalent bandwidth over which the -0.4 dBW input power to the 1.8 m antenna would be spread in normal operation of a third generation AIF is then 10^(-0.4/10)/10^(-24.3/10) = 245.5 MHz.

To calculate the power density in dBW/MHz, the bandwidth adjustment in dB is calculated as 10 log (245.5 MHz/1 MHz) = 23.9 dB(MHz). This result is subtracted from the measured value to calculate the power density. For Site 1, this is -137.51 dBW – 23.9 dB(MHz) = -161.41 dBW/MHz.

To complete the conversion from power density to power flux density (pfd), the meter squared area gain is added to the power density.

Meter squared area gain = $10 \log \frac{4\pi}{\lambda^2} = 50.46$ dB/m^2 (3)

The measured pfd is then -161.41 dBW/MHz + 50.46 dB/m^2 = -111 dBW/(m^2 * MHz), or -81 dBm/(m^2 * MHz).

The conversion process was repeated for each of the measurement sites and measurement heights (2 m and 10 m) and the results were recorded in Table 2.

Measurement Location	Measurement Height (m)	Recorded Signal (dBW)			Power Density (dBW/MHz)	Power Flux Density (dBW/(m^2*MHz)		
Site 1	10	-137.51			-161.44			-110.98
Site 1	2	-158.19	NF		-182.12		≪	-131.66
Site 2	10	-149.10			-173.03			-122.57
Site 2	2	-155.56	NF		-179.49		≪	-129.03
Site 3	10	-141.30			-165.23			-114.77
Site 3	2	-159.65	NF		-183.58		≪	-133.12
Site 4	10	-133.25			-157.18			-106.72
Site 4	2	-160.00	NF		-183.93		≪	-133.47
Site 5	10	-140.68			-164.61			-114.15
Site 5	2	-147.78			-171.71			-121.25
Site 6	10	-144.95			-168.88			-118.42
Site 6	2	-154.82			-178.75			-128.29
Site 7	10	-155.96	NF		-179.89		≪	-129.43
Site 7	2	-158.19	NF		-182.12		≪	-131.66
Site 8	10	-158.63	NF		-182.56		≪	-132.10
Site 8	2	-158.63	NF		-182.56		≪	-132.10
Site 9	10	-158.10	NF		-182.03		≪	-131.57
Site 9	2	-159.44	NF		-183.37		≪	-132.91
Site 10	10	-158.60	NF		-182.53		≪	-132.07
Site 10	2	-158.77	NF		-182.70		≪	-132.24
Site 11	10	-157.48	NF		-181.41		≪	-130.95
Site 11	2	-158.78	NF		-182.71		≪	-132.25

Table 2 Calculated Power Flux Density for Measurement Locations

Examining the results in Table 2 it can be seen that all but one measured value was below the *Spectrum Frontiers Order* sharing criteria limit of -77.6 dBm/(m^2 * MHz). The measured value for Site 4 which had the highest terrain and lowest additional losses, was the only value which exceeded the FCC limit. The exceedance of the limit by 0.9 dB, would easily be mitigated by a modest increase in the parapet wall on that side of the building where terrain is higher.

Conclusion

While the transmitting antenna tested here normally operates in the conventional Ka band, and accordingly was not sited with 5G/UMFU sharing constraints in mind, this type of roof top mounting scenario is quite common for modest sized earth stations in urban or suburban commercial settings. Even with no special care taken to mitigate signal levels toward the horizon, the measured levels for all but one location were below the FCC's sharing criteria, and in many cases significantly so.

With some care used in new installations, it would be fairly easy to shield the antenna from nearby 5G/UMFU operations and thereby allow siting of earth stations close to fiber even in urban environments where 5G/UMFU will be or has deployed.

DECLARATION

I hereby declare that I am the technically qualified person responsible for preparation of the engineering information contained in this report, that I am familiar with Part 25 of the Commission's rules, that I have either prepared or reviewed the engineering information submitted with this report, and that it is complete and accurate to the best of my knowledge, information and belief.

Daryl T. Hunter, P.E.
Senior Director, Regulatory Affairs
ViaSat, Inc.
6155 El Camino Real
Carlsbad, CA 92009

April 12, 2017

Annex 1 – Comsearch Report

RADIO FREQUENCY SIGNAL MEASUREMENT REPORT

Prepared For

ViaSat

Carlsbad, CA

Transmit Station
28 GHz

February 2017

19700 Janelia Farm Boulevard. - Ashburn, Virginia 20147, USA - 703.726.5500 - Fax 703.726.5597

TABLE OF CONTENTS

SECTION

ONE

SECTION 1

INTRODUCTION AND BACKGROUND

1.1 Introduction

On-site Radio Frequency (RF) transmission measurements were performed on behalf of ViaSat, Inc. on February 14,2017 at their existing site in Carlsbad, CA. The purpose of the measurements was to determine relative RF levels in the 27.5-28.35 GHz band with respect to expected free space loss and to evaluate the effectiveness of using a typical rooftop earth station installation to screen transmissions from nearby terrestrial receivers. The purpose of this report is to document the results of these measurements:

- 1.8 Meter TX Antenna
- Satellite Arc: 111.1 Degrees West Longitude
- Frequency Considered: 28,212.5 MHz
- Transmit Power: 1 Watt / 30 dBm
- Type of Reception: CW
- Measured Rx Antenna Center Line: 10 meters Above Ground Level

1.2 Background

ViaSat, Inc requested that Comsearch perform receive level testing using a calibrated system to measure receive signal levels from a CW carrier being transmitted from a rooftop mounted 1.8-meter antenna in the areas surrounding the antenna. The antenna is located on the roof of a 3 story building, in the center portion of the roof, in a depressed area. The coordinates of the test transmit antenna are: 33° 0 7' 38.31"N and 117° 15' 55.13"W. The roof has a short parapet wall (varying between approximately 1.5 feet and 3 feet) at the edge but no other substantial items which would provide blockage. The antenna is located in a depression in the roof which is approximately 2.5 feet deep.

An unmodulated CW carrier was used because previous testing at ground level using a modulated carrier had resulted in no detectable signals. By using a CW carrier, the power density in the measurement bandwidth was increased considerably. Additionally, testing at both ground level (2 m) and 10 m were requested for the new tests in order to improve the likelihood of detecting a signal above the noise floor of the measuring equipment.

The ground test locations were determined by drawing multiple arcs at 50 meter distances from the building and where those circles intersected with the main beam, 45 and 90 degree off main beam locations. Tests were conducted as close as possible to those crossings where possible. Because of the lack of signals above the noise floor during previous tests and the difficulty of crossing the busy roadway to the West of the antenna with the boom lift, testing on that side of the street was planned only if testing there was deemed warranted.

The measurement sites are identified on a portion of a topographic map shown in Figure 1.2-1. An aerial photo of the site locations are shown in Figure 1.2-2.

1.3 <u>Assumptions &Constraints</u>

The analysis in this report is based upon the following assumptions and constraints.

- It was verified that during the measurement period the transmit antenna was active and operating at the specified transmit power ±1 dB.
- The signal identification and frequencies of the test carrier were specified by ViaSat.
- The actual ground elevation of the site is based on the data from the topographic map.

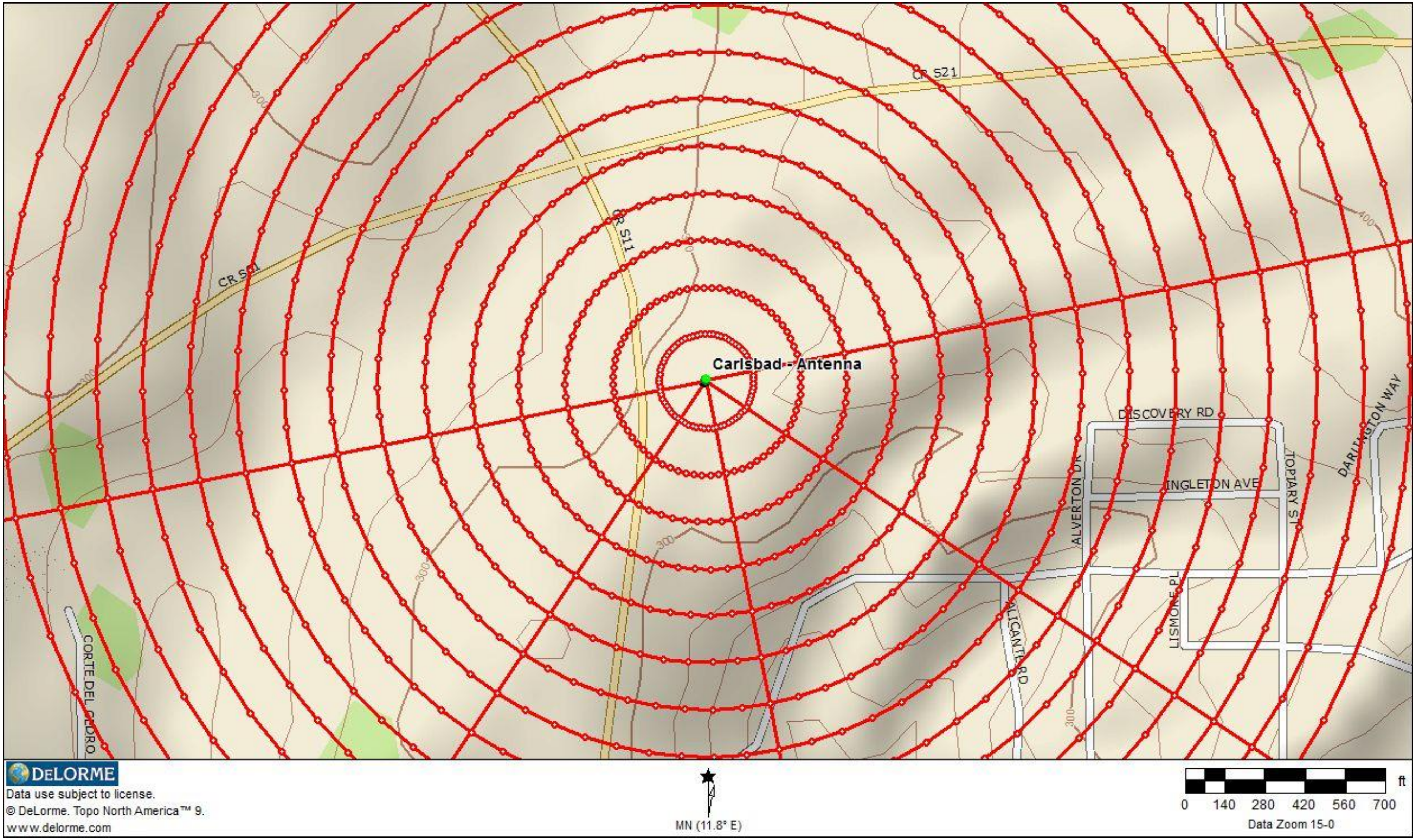
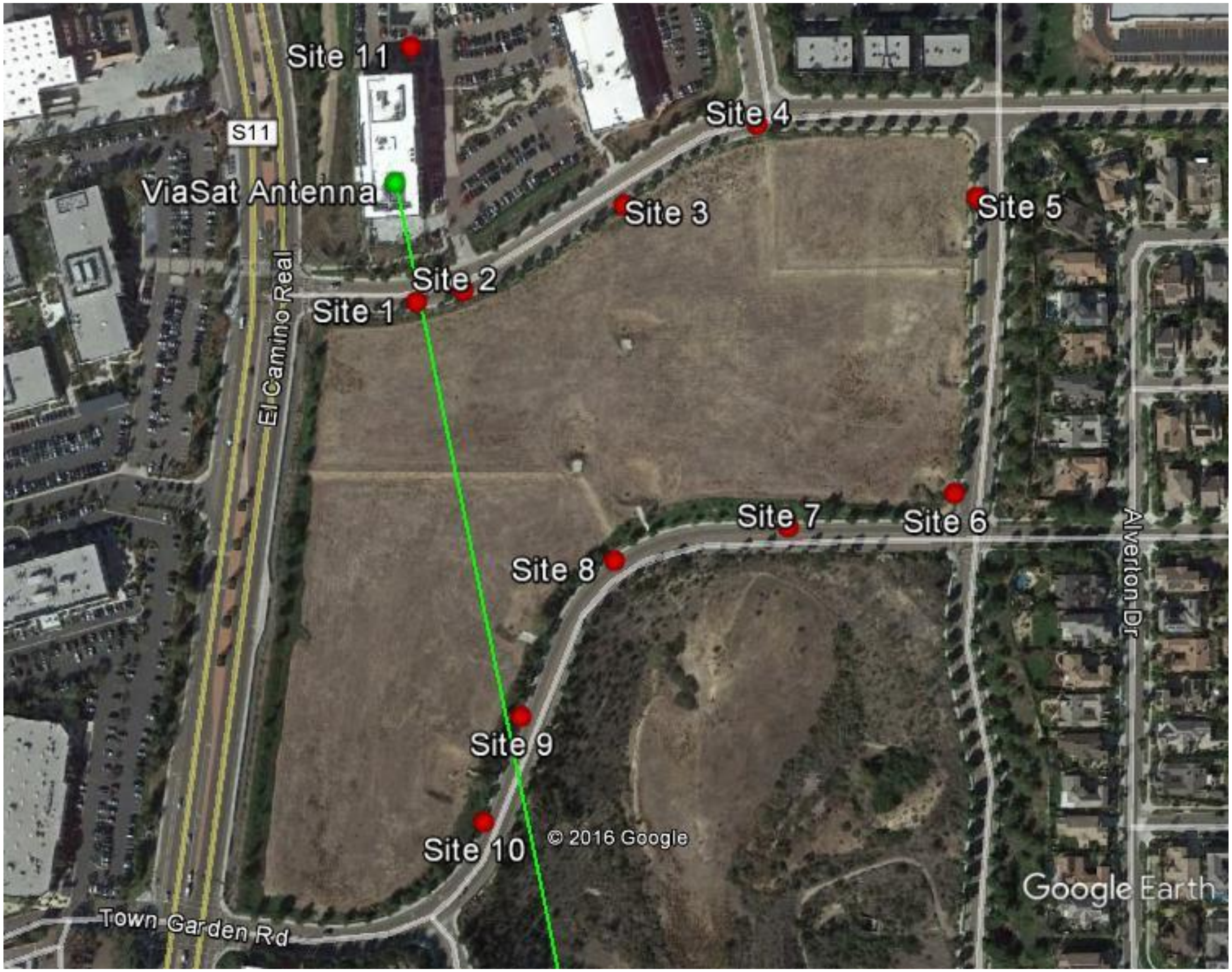


Figure 1.2-1 – Topographic Map



The green line is the main beam azimuth. Red dots show measurement locations,

Figure 1.2-2 – Aerial Photograph

SECTION

TWO

SECTION 2

TEST PROCEDURE

2.1 Calibration

Figures 2.1-1 is the block diagram of the test set for all bands to be tested. All test equipment used was allowed a proper warm-up period prior to calibration. The test set was calibrated by the signal substitution method, as recommended by NSMA, utilizing a synthesized signal generator. The reference signal from the signal generator was adjusted for the center frequency of each band to be tested and measured with a thermal power meter for calibrated reference test level (-60 dBm). This calibrated reference signal from the signal generator was then injected into the end of the coaxial cable of the test set at the point, which normally connects to the test antenna. A spectrum analyzer then measured the reference test signal level after passing through the test set. Upon completion of the calibration process, a known reference level was obtained for the measurements that correspond to a given set of spectrum analyzer display readings.

The following formula is used to transform the measured signal level as read on the spectrum analyzer display (dBm) to an isotropic reference signal level (dBW_I) as seen at the point of test:

$$dBW_I = LI - EG - 30$$

Where: dBW_I = Isotropic level in dBW

LI = Level (dBm) of injected signal

EG = External Gain = Test antenna gain + LNA Gain

at 28 GHz: $dBW_I = -60\text{ dBm} - 45.9\text{ dB}$

$= -105.9\text{ dBm}_I$

In this instance, the spectrum analyzer displayed measured signal level of –60 dBm equates to an isotropic signal level of –105.9 dBm_I.

Figure 2.1-2 displays the spectrum photograph of the described calibration procedure employed during these measurements.

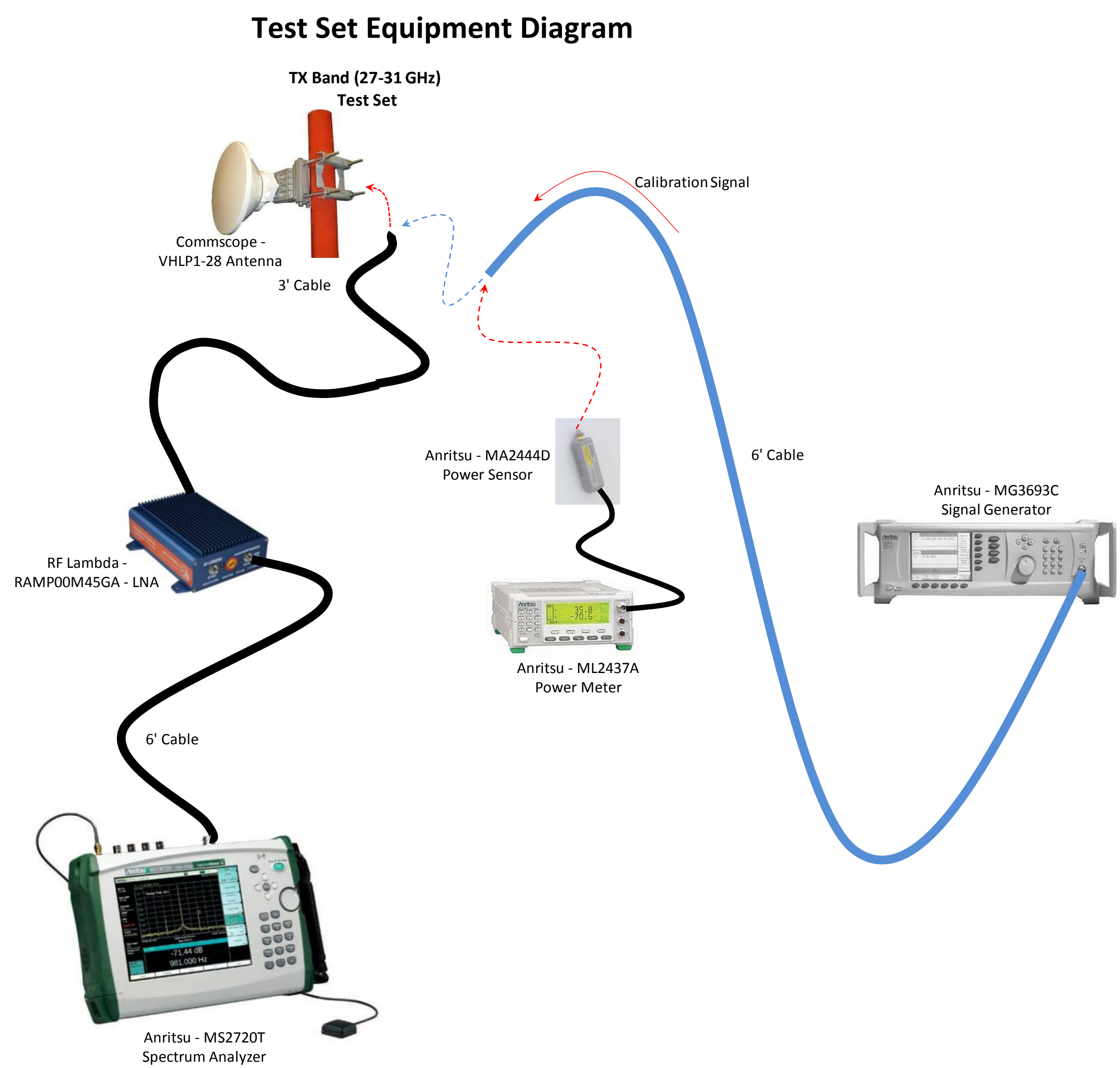
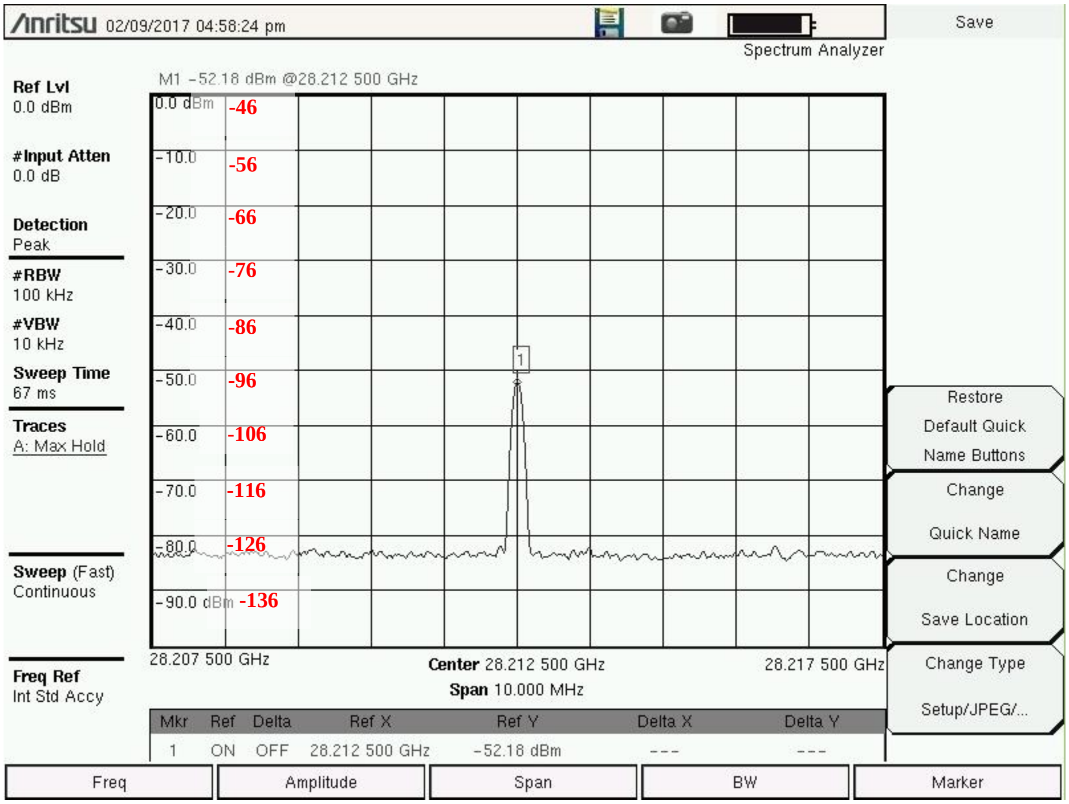


Figure 2.1-1 Receive Test Equipment Block Diagram



A -52.18 dBm , 28212.5 MHz signal indication on the spectrum photograph represents a -60 dBm signal being injected at the point where the test cable connects to the output of the test antenna.

Displayed reference level is equal:
-60 dBm injected signal
-45.9 dB external gain
-105.9 dBm_I; therefore, a displayed
signal level of -70 dBm equals an
isotropic level of -116 dBm_I

Adjusted measurement values (dBm_I) shown in red

Figure 2.1-2 Calibration Spectrum Photo 28 GHz

2.2 Methodology

The test equipment was set up and calibrated to measure the RF environment. Measurements were conducted at in such a way that would show if the signal from the transmitter was visible above the test equipment's noise floor for the 27.5-28.35 GHz band. After the equipment calibration was completed, the test antenna was mounted on a motorized boom lift and elevated to a height of 10 meters AGL. The tests were conducted by activating the peak hold function of the spectrum analyzer. This enabled the analyzer to maintain and display the maximum signal level received for the frequency under consideration. The test antenna was peaked while pointed at the transmit antenna to attempt to receive any signal from the transmit antenna. "

Table 3.1-1, item 8. The area on the roof where the TX antenna is located is depressed by approximately 2.5 ft deep.

In tables 4.1 & 4.1, NF = Noise Floor of test measurement system. (So readers won't confuse this with 5G or LMDS equipment NF).

SECTION

THREE

SECTION 3

DATA PRESENTATION

The following section contains the tables and spectrum photos pertaining to the site location measured**.**

3.1 Carlsbad, CA

- Table 3.1-1 presents a site data sheet including all pertinent site information.

- Figures 3.1-1 and 3.1-2 are the photographs depicting the existing earth station site and test locations.

- Figures 3.1-3 (A) through 3.1-3 (V) are the RF spectrum photographs depicting the receive signal measured at the test sites.

TABLE 3.1-1

MEASUREMENT SITE DATA SHEET

1. SYSTEM NAME:	ViaSat, Inc	
2. CITY AND STATE:	Carlsbad, CA	
3. SITE IDENTIFICATION:	Carlsbad	
4. COORDINATES (TX Site):	LATITUDE:	33° 07' 38.31" N
(NAD 1983)	LONGITUDE:	117°15' 55.13" W
5. GROUND ELEVATION:	310 feet AMSL	
6. MEASUREMENT DATE:	February 14, 2017	
7. GEOSTATIONARY ARC RANGE:		
SATELLITE POSITIONS:	111.1° W	
AZIMUTH:	168.8°	
ELEVATION:	50.9°	

8. GEOSTATIONARY ARC VISIBILITY: The TX site is on a 3 story building with a short parapet wall. The TX antenna was also in an area of the roof that is depressed approximately 3 feet.

View of transmit antenna looking north

View of transmit antenna looking south

Figure 3.1-1 (cont.) Earth Station Site Photographs

View of transmit antenna looking south

View of transmit antenna looking west

Figure 3.1-1 (cont.) Earth Station Site Photographs

View from rooftop looking east

View from rooftop looking southeast

Figure 3.1-1(cont.) Earth Station Site Photographs

View from rooftop looking south

View from rooftop looking southwest

Figure 3.1-1 (cont.) Earth Station Site Photographs

View toward TX antenna on rooftop from Site 1 at 10m AGL

View toward TX antenna on rooftop from Site 1 at 10m AGL (zoom)

Figure 3.1-2 Test Locations

View toward TX antenna on rooftop from Site 2 at 10m AGL

View toward TX antenna on rooftop from Site 2 at 10m AGL (zoom)

Figure 3.1-2 (cont.) Test Locations

View toward TX antenna on rooftop from Site 3 at 10m AGL

View toward TX antenna on rooftop from Site 3 at 10m AGL (zoom)

Figure 3.1-2 (cont.) Test Locations

View toward TX antenna on rooftop from Site 4 at 10m AGL

View toward TX antenna on rooftop from Site 4 at 10m AGL (zoom)

Figure 3.1-2 (cont.) Test Locations

View toward TX antenna on rooftop from Site 5 at 10m AGL

View toward TX antenna on rooftop from Site 5 at 10m AGL (zoom)

Figure 3.1-2 (cont.) Test Locations

View toward TX antenna on rooftop from Site 6 at 10m AGL

View toward TX antenna on rooftop from Site 6 at 10m AGL (zoom)

Figure 3.1-2 (cont.) Test Locations

View toward TX antenna on rooftop from Site 7 at 10m AGL

View toward TX antenna on rooftop from Site 7 at 10m AGL (zoom)

Figure 3.1-2 (cont.) Test Locations

View toward TX antenna on rooftop from Site 8 at 10m AGL

View toward TX antenna on rooftop from Site 8 at 10m AGL (zoom)

Figure 3.1-2 (cont.) Test Locations

View toward TX antenna on rooftop from Site 9 at 10m AGL

View toward TX antenna on rooftop from Site 9 at 10m AGL (zoom)

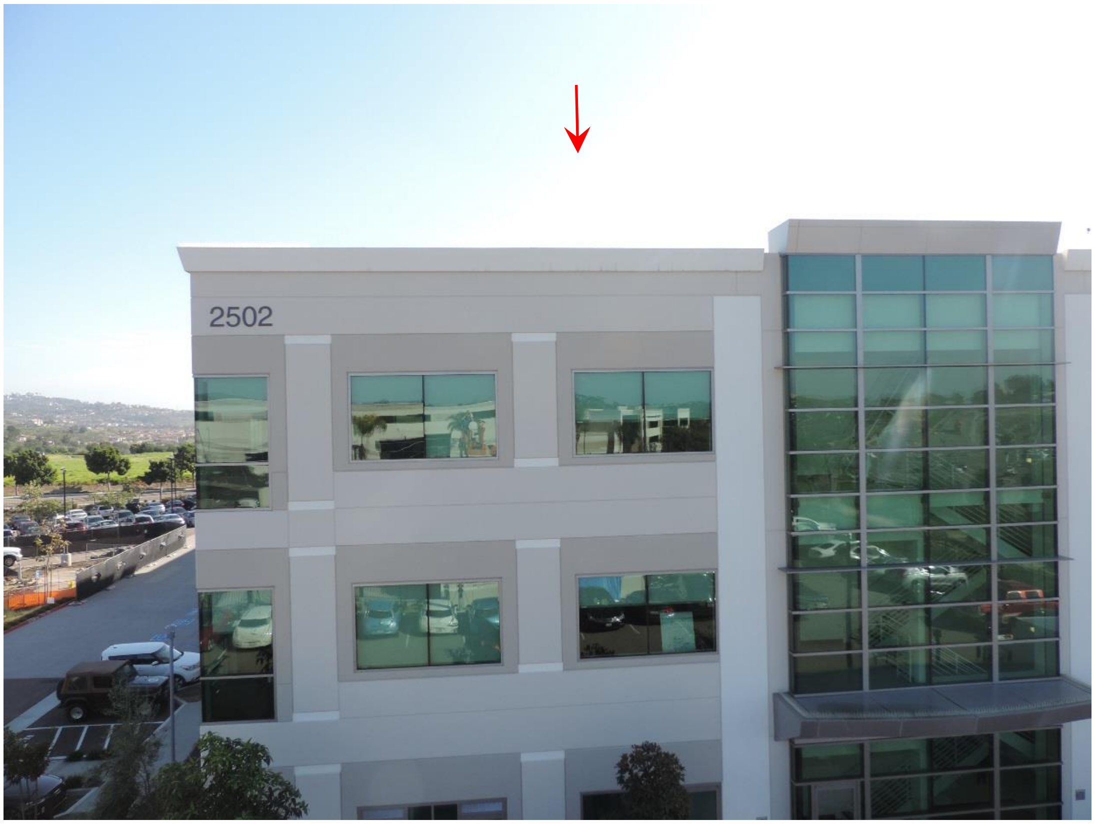
Figure 3.1-2 (cont.) Test Locations

View toward TX antenna on rooftop from Site 10 at 10m AGL

View toward TX antenna on rooftop from Site 10 at 10m AGL (zoom)

Figure 3.1-2 (cont.) Test Locations

View toward TX antenna on rooftop from Site 11 at 2m AGL



View toward TX antenna on rooftop from Site 11 at 10m AGL (zoom)

Figure 3.1-2 (cont.) Test Locations

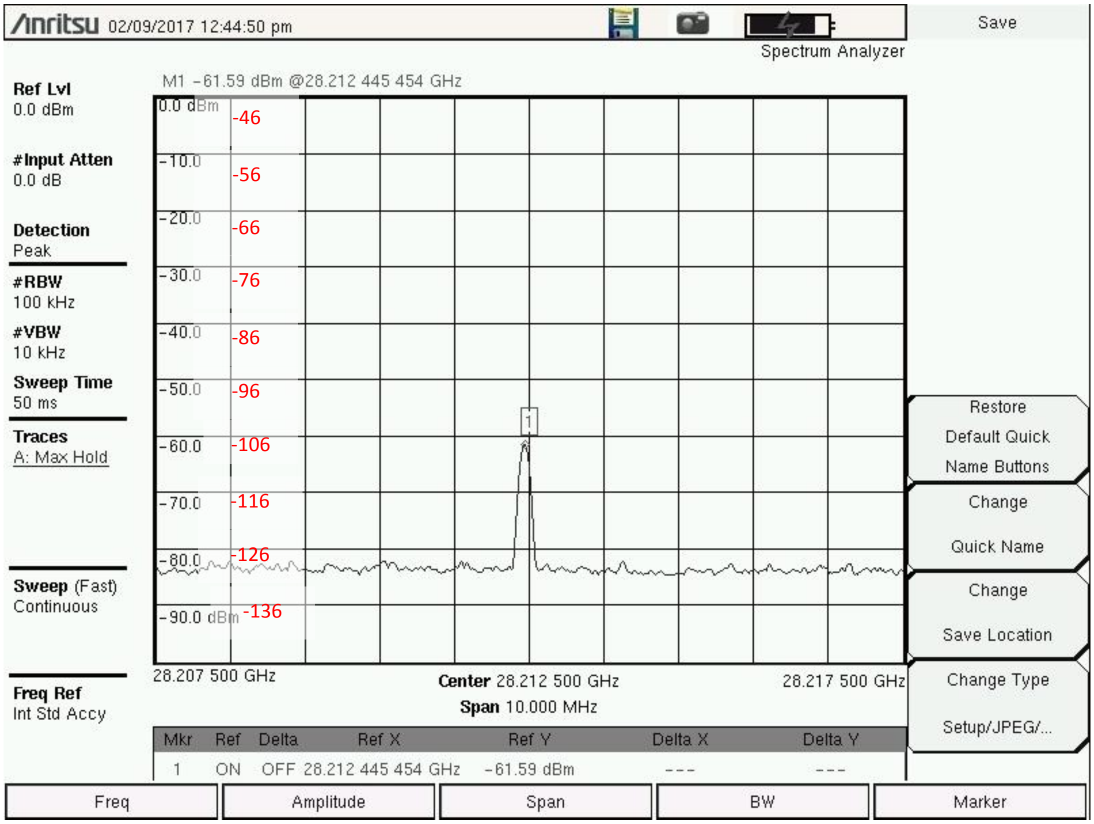


Figure 3.1-3 (A) Spectrum Photos 28 GHz - 100 kHz Res BW Site 1 at 10m AGL

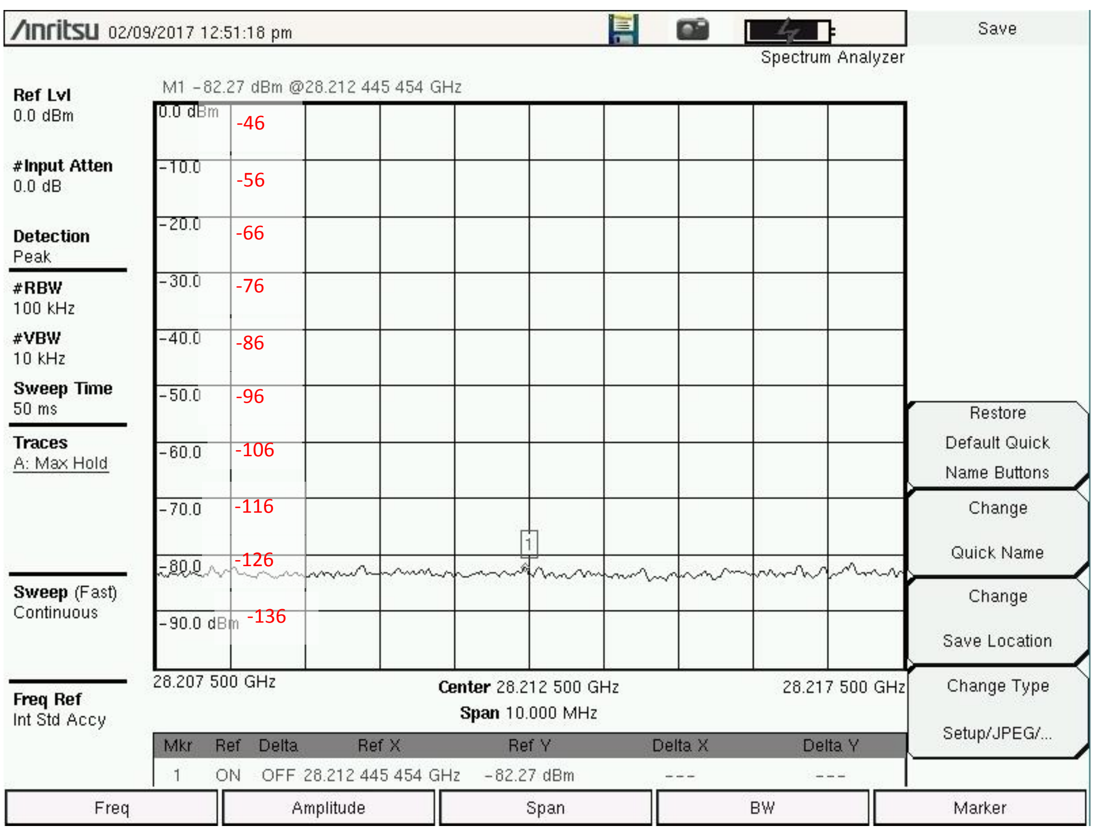


Figure 3.1-3 (B) Spectrum Photos 28 GHz - 100 kHz Res BW Site 1 at 2m AGL

Adjusted measurement values (dBm_I) shown in red

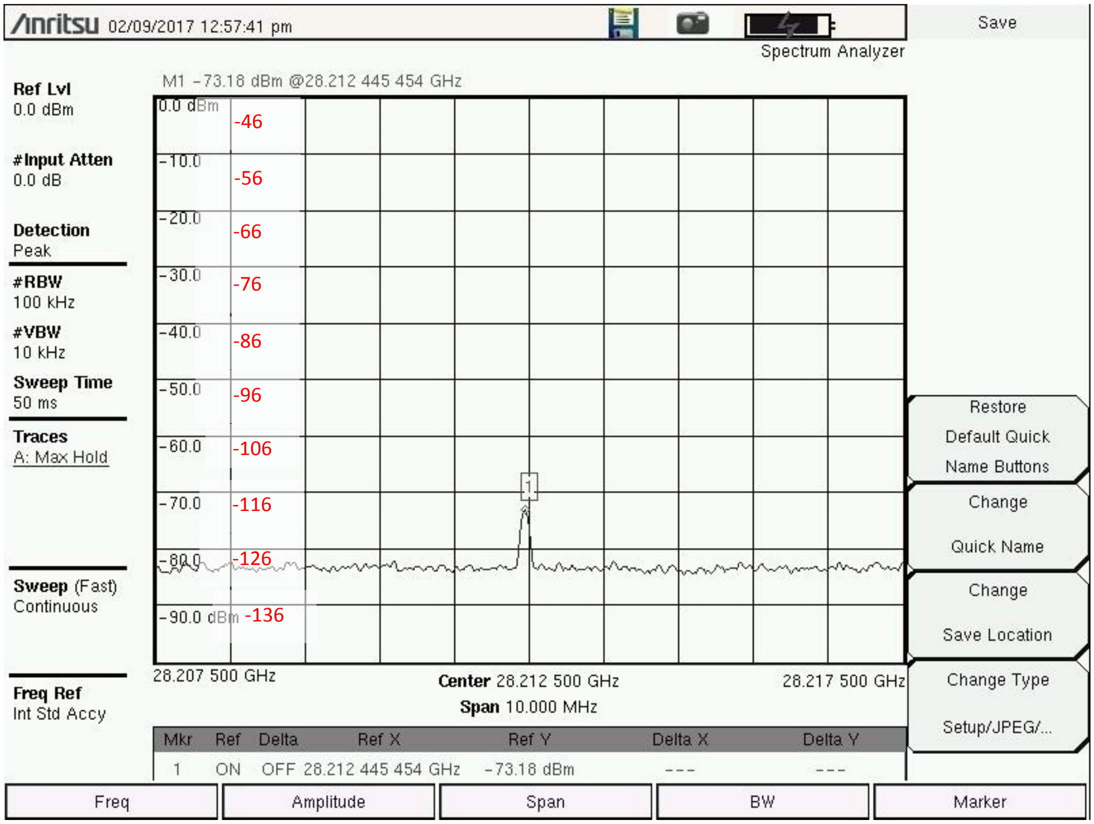


Figure 3.1-3 (C) Spectrum Photos 28 GHz - 100 kHz Res BW Site 2 at 10m AGL

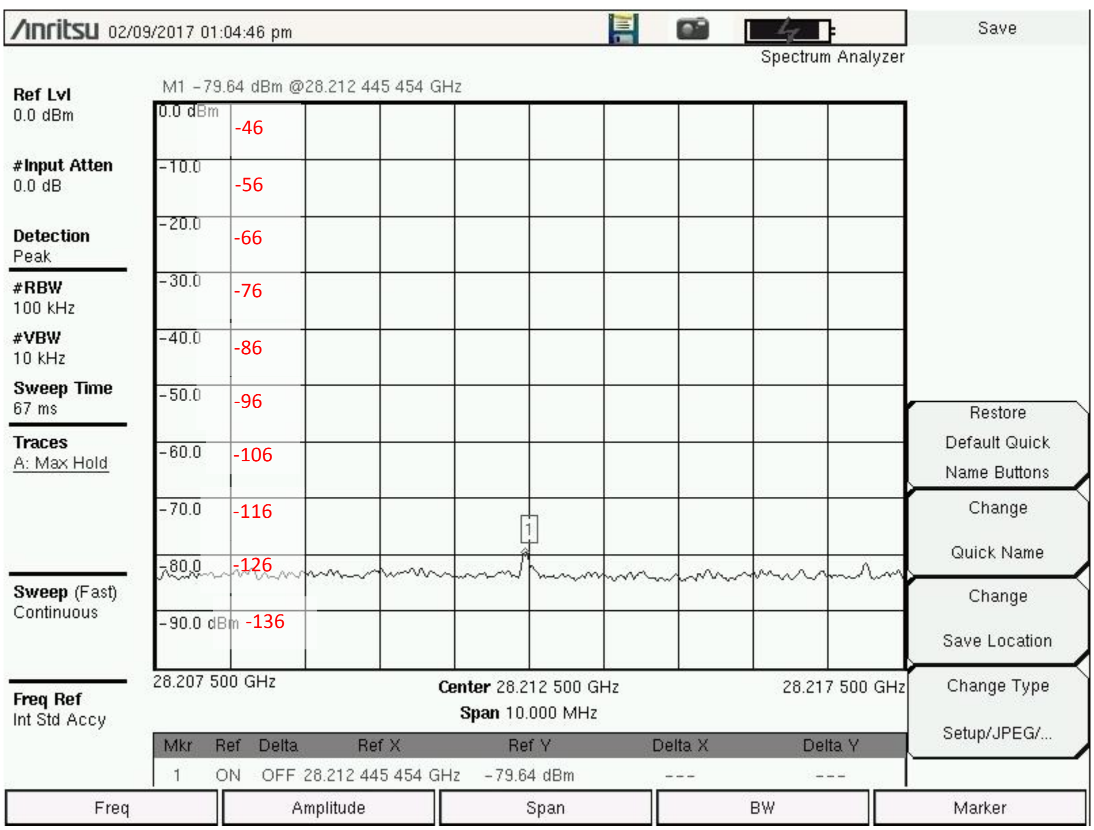


Figure 3.1-3 (D) Spectrum Photos 28 GHz - 100 kHz Res BW Site 2 at 2m AGL

Adjusted measurement values (dBm_I) shown in red

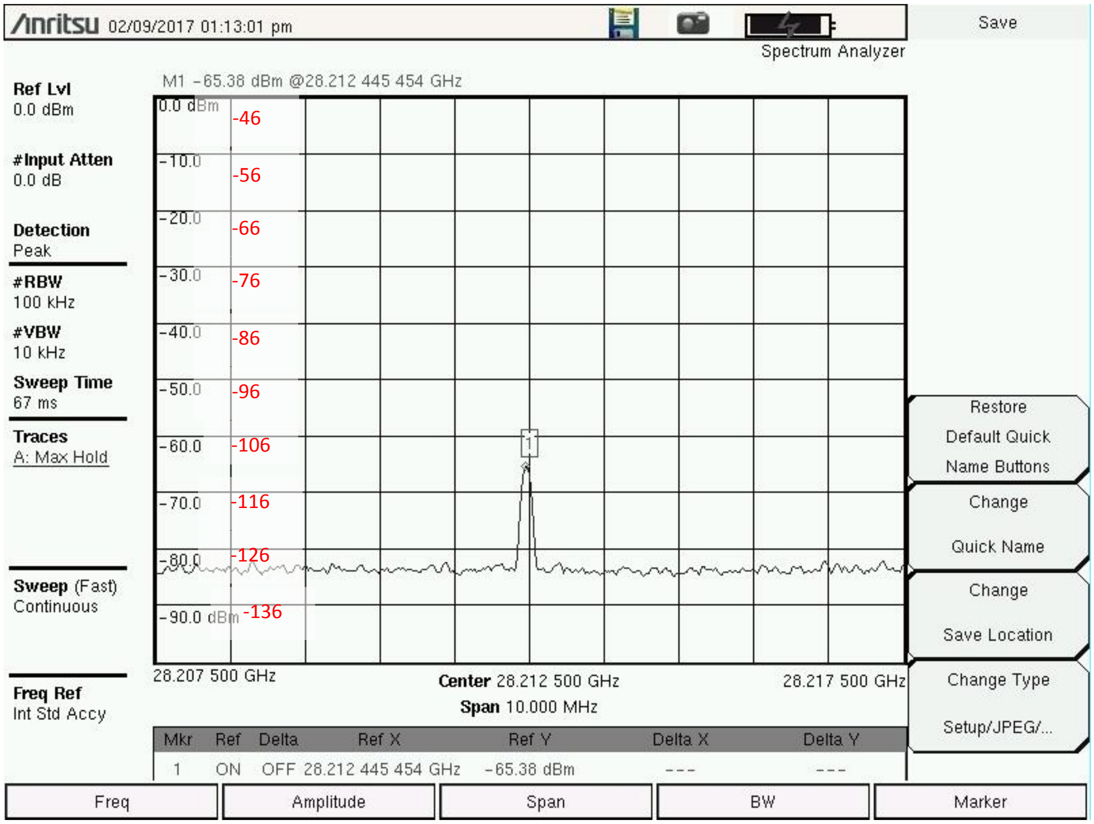


Figure 3.1-3 (E) Spectrum Photos 28 GHz - 100 kHz Res BW Site 3 at 10m AGL

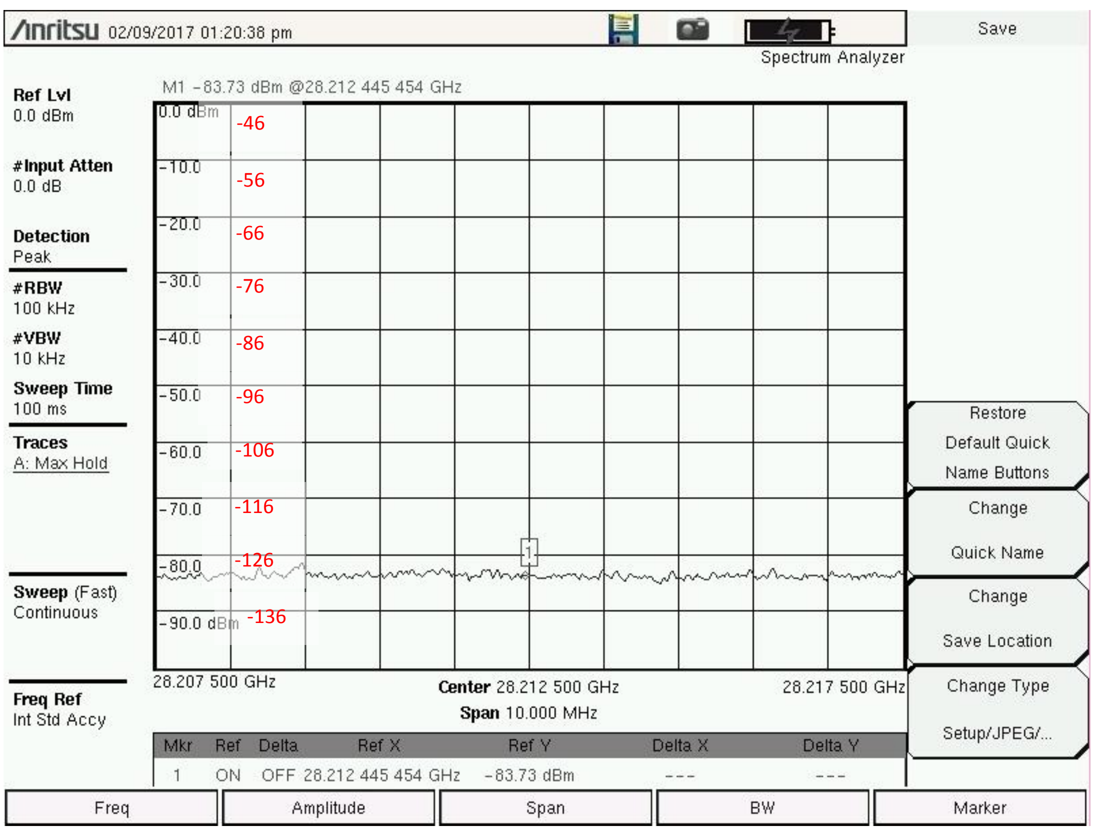


Figure 3.1-3 (F) Spectrum Photos 28 GHz - 100 kHz Res BW Site 3 at 2m AGL

Adjusted measurement values (dBm_I) shown in red

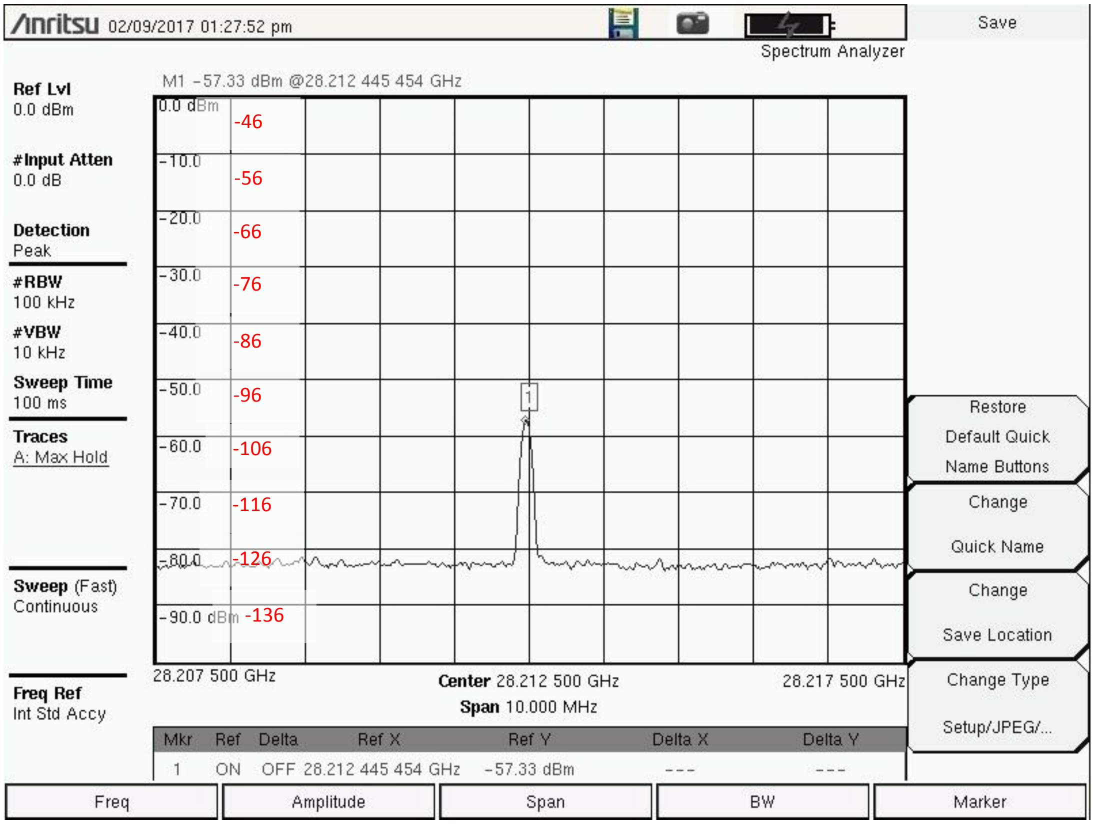


Figure 3.1-3 (G) Spectrum Photos 28 GHz - 100 kHz Res BW Site 4 at 10m AGL

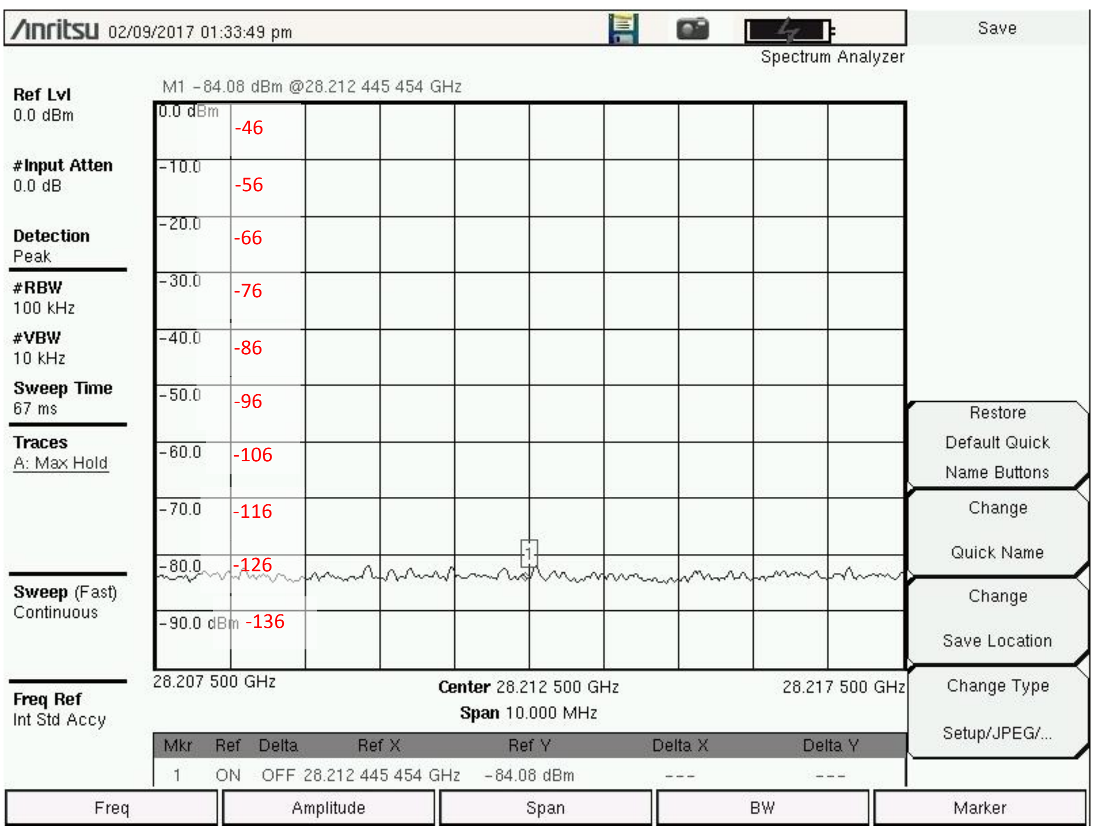


Figure 3.1-3 (H) Spectrum Photos 28 GHz - 100 kHz Res BW Site 4 at 2m AGL

Adjusted measurement values (dBm_I) shown in red

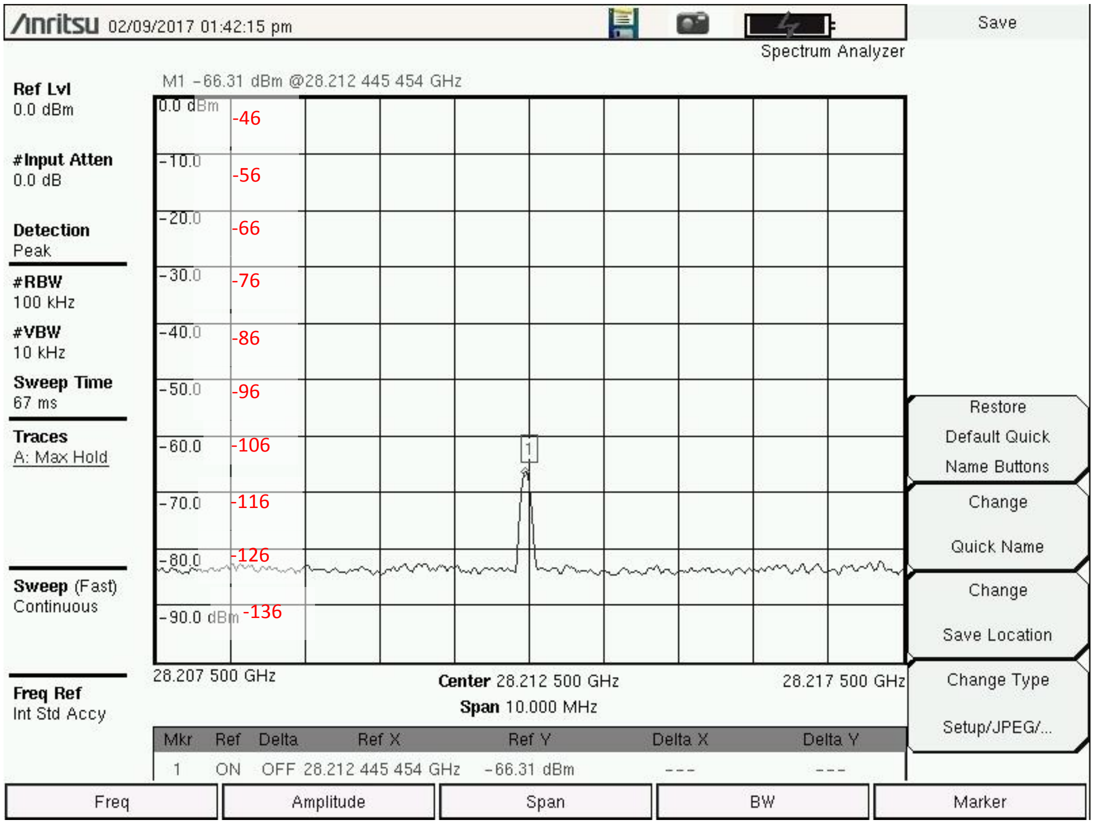


Figure 3.1-3 (I) Spectrum Photos 28 GHz - 100 kHz Res BW Site 5 at 10m AGL

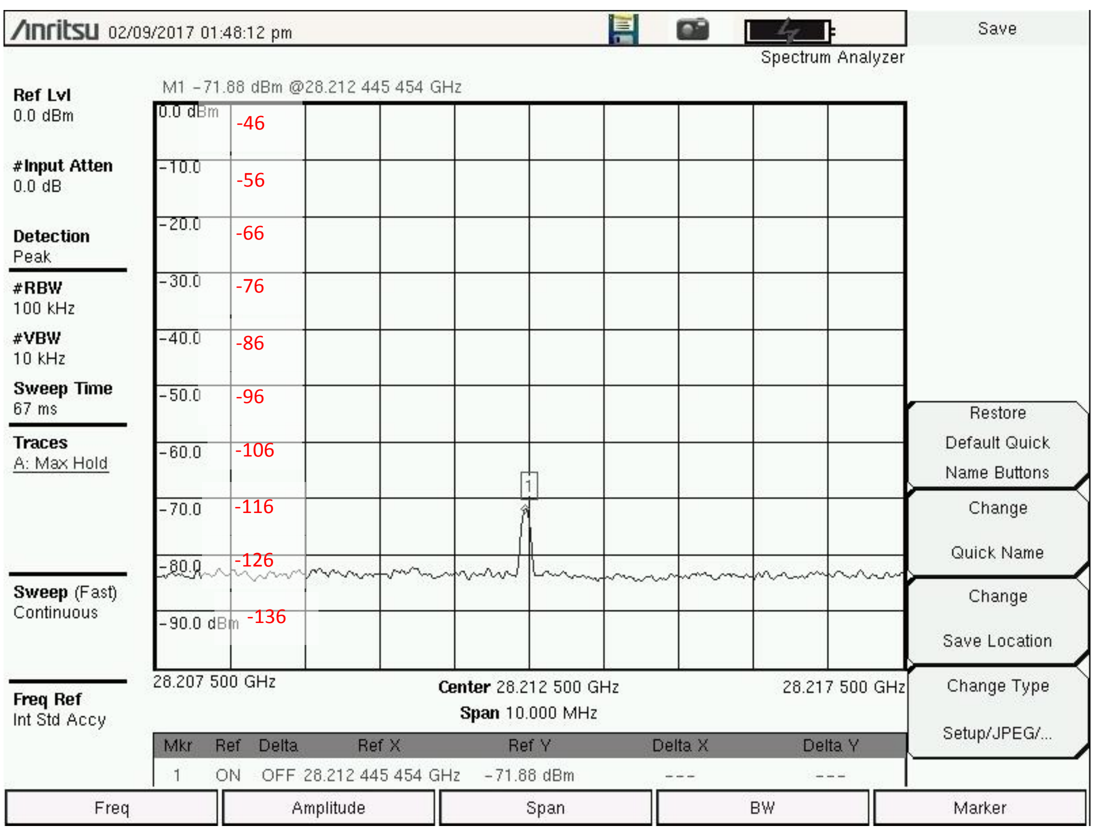


Figure 3.1-3 (J) Spectrum Photos 28 GHz - 100 kHz Res BW Site 5 at 2m AGL

Adjusted measurement values (dBm_I) shown in red

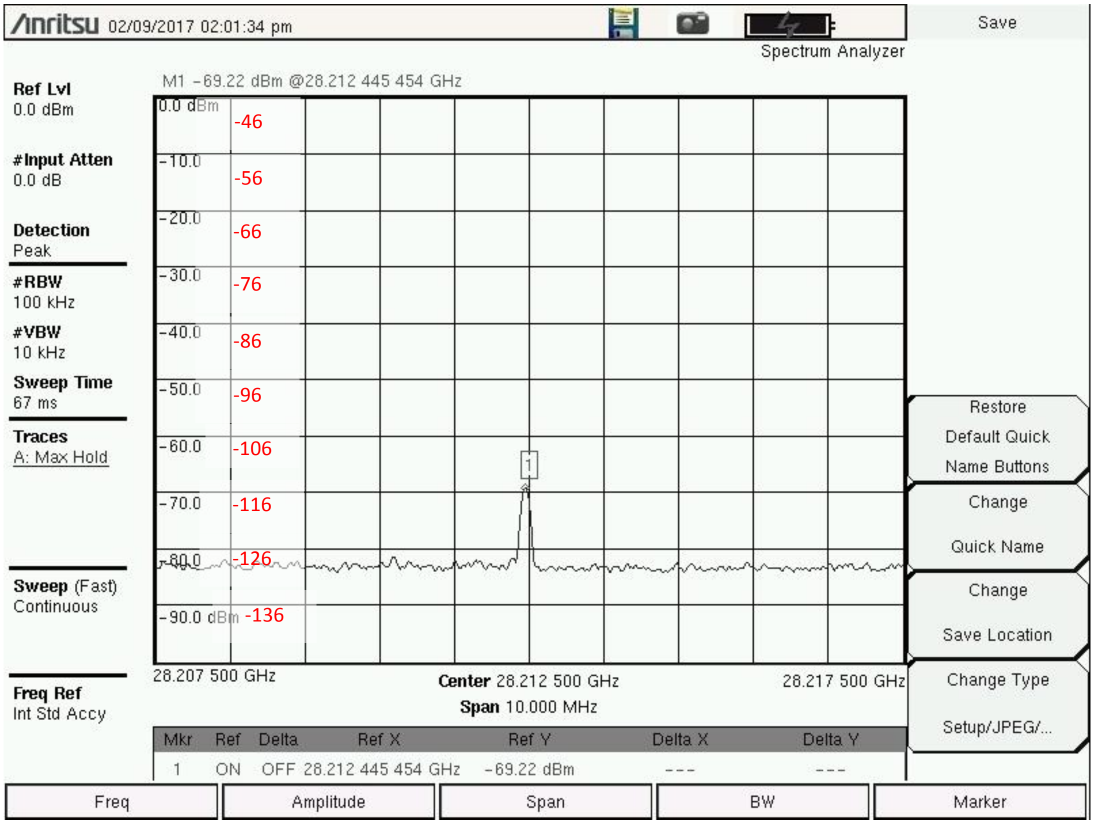


Figure 3.1-3 (K) Spectrum Photos 28 GHz - 100 kHz Res BW Site 6 at 10m AGL

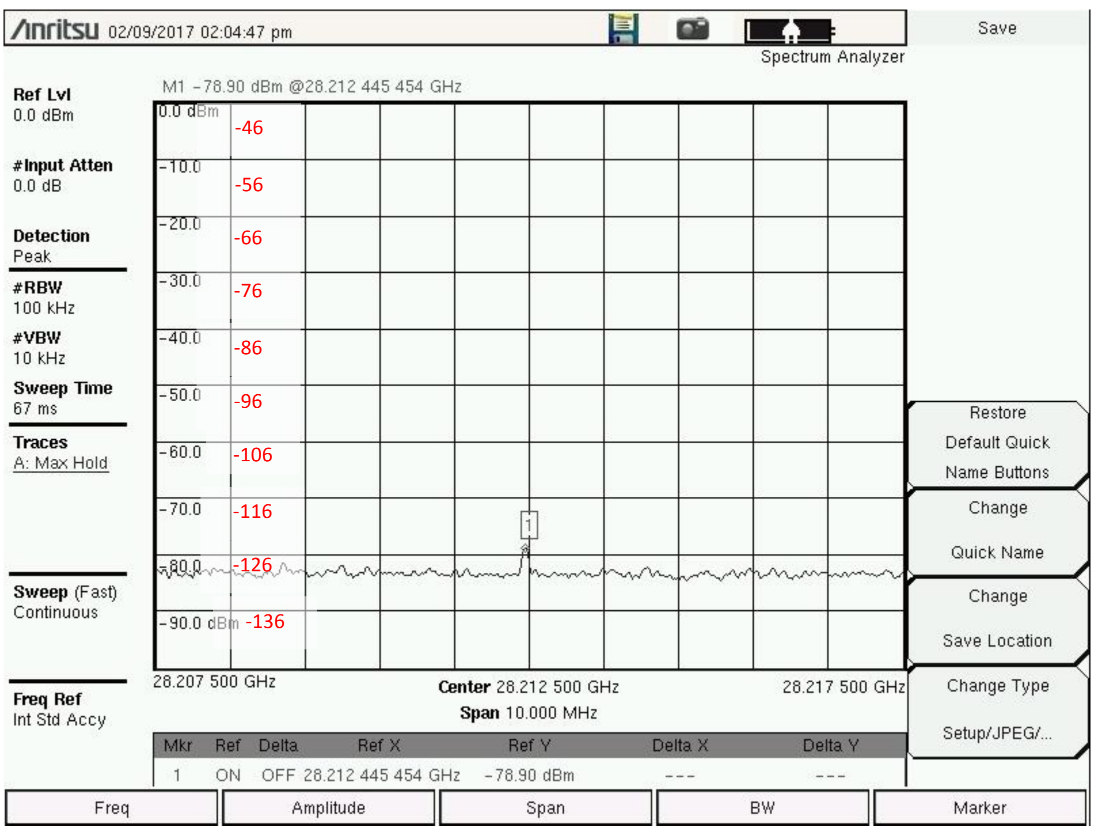


Figure 3.1-3 (L) Spectrum Photos 28 GHz - 100 kHz Res BW Site 6 at 2m AGL

Adjusted measurement values (dBm_I) shown in red

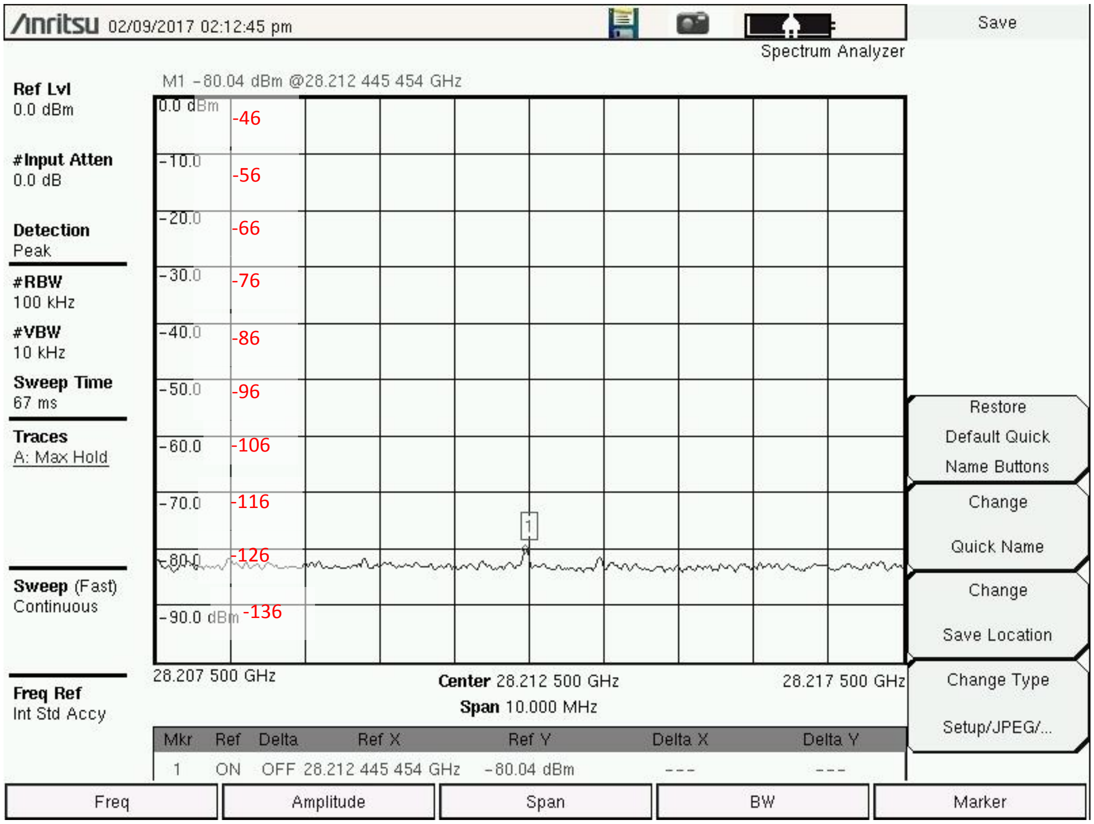


Figure 3.1-3 (M) Spectrum Photos 28 GHz - 100 kHz Res BW Site 7 at 10m AGL

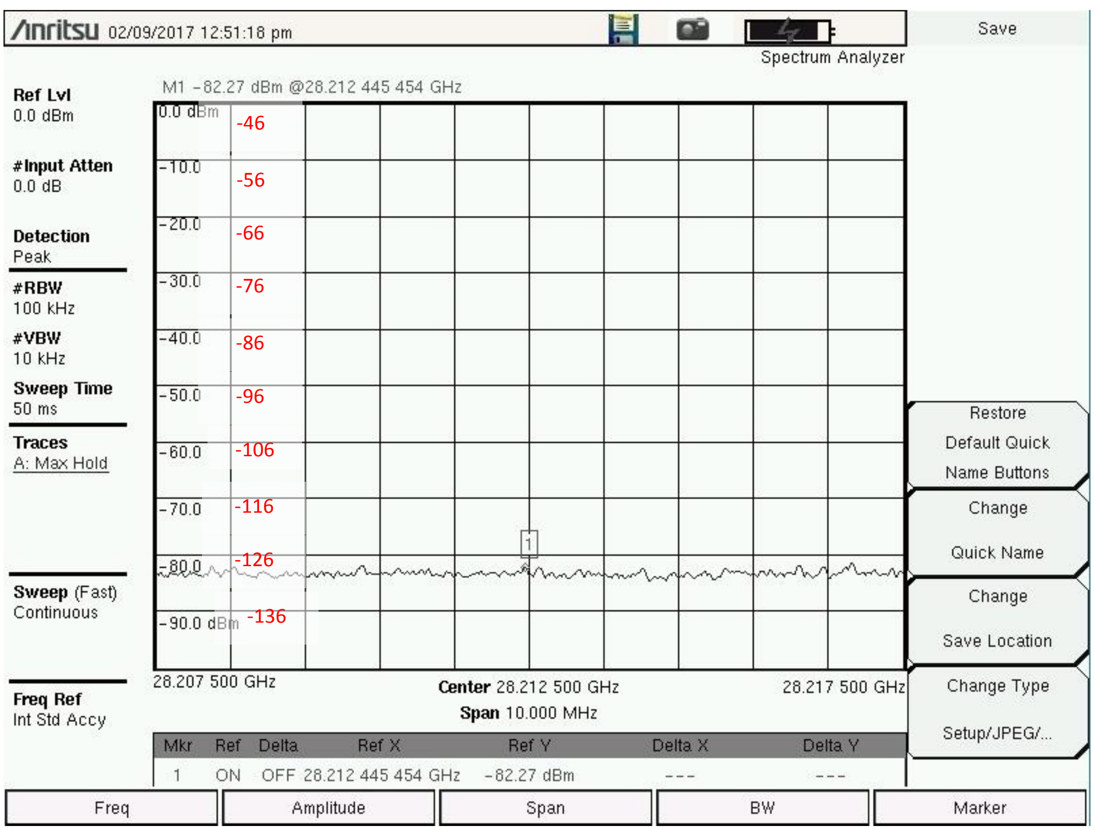


Figure 3.1-3 (N) Spectrum Photos 28 GHz - 100 kHz Res BW Site 7 at 2m AGL

Adjusted measurement values (dBm_I) shown in red

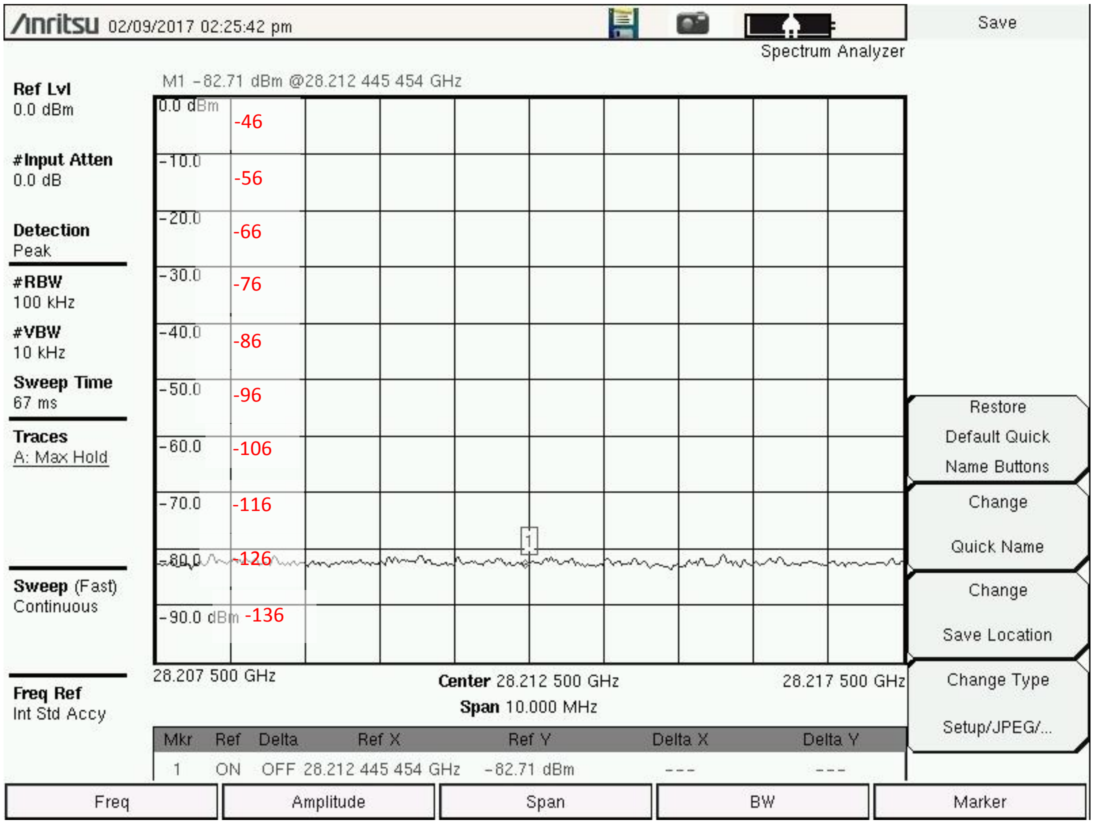


Figure 3.1-3 (O) Spectrum Photos 28 GHz - 100 kHz Res BW Site 8 at 10m AGL

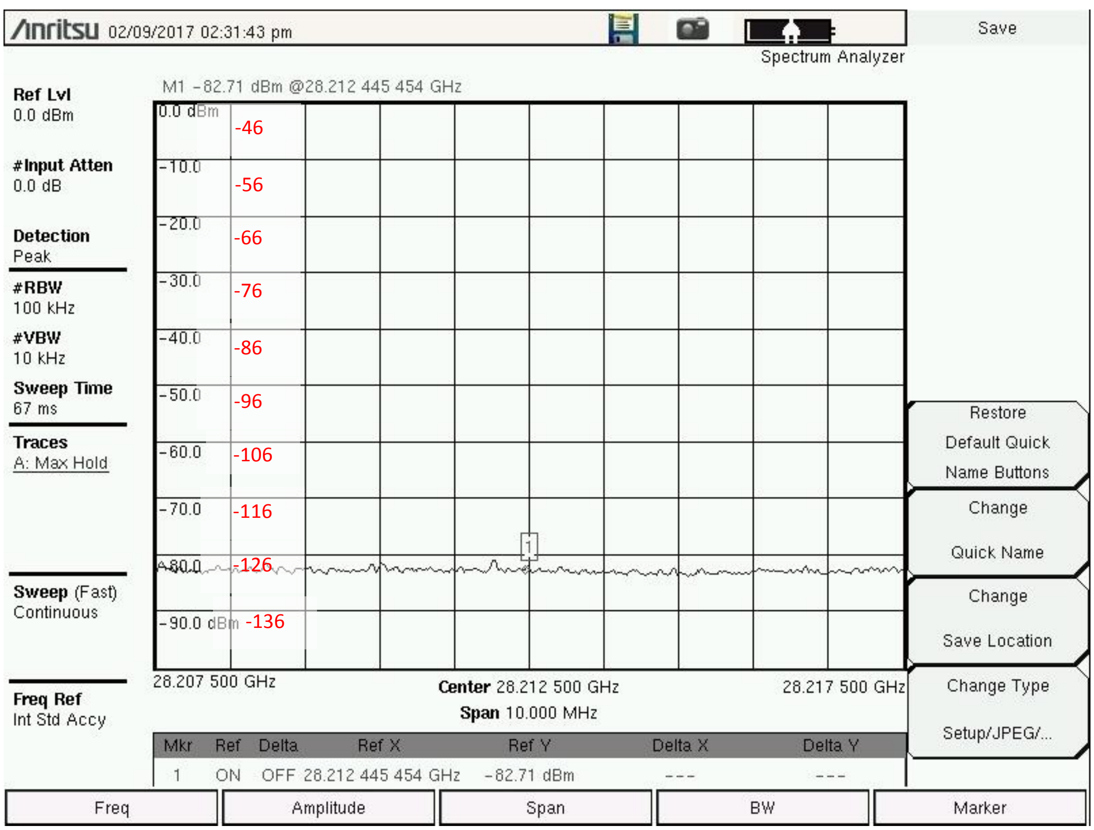


Figure 3.1-3 (P) Spectrum Photos 28 GHz - 100 kHz Res BW Site 8 at 2m AGL

Adjusted measurement values (dBm_I) shown in red

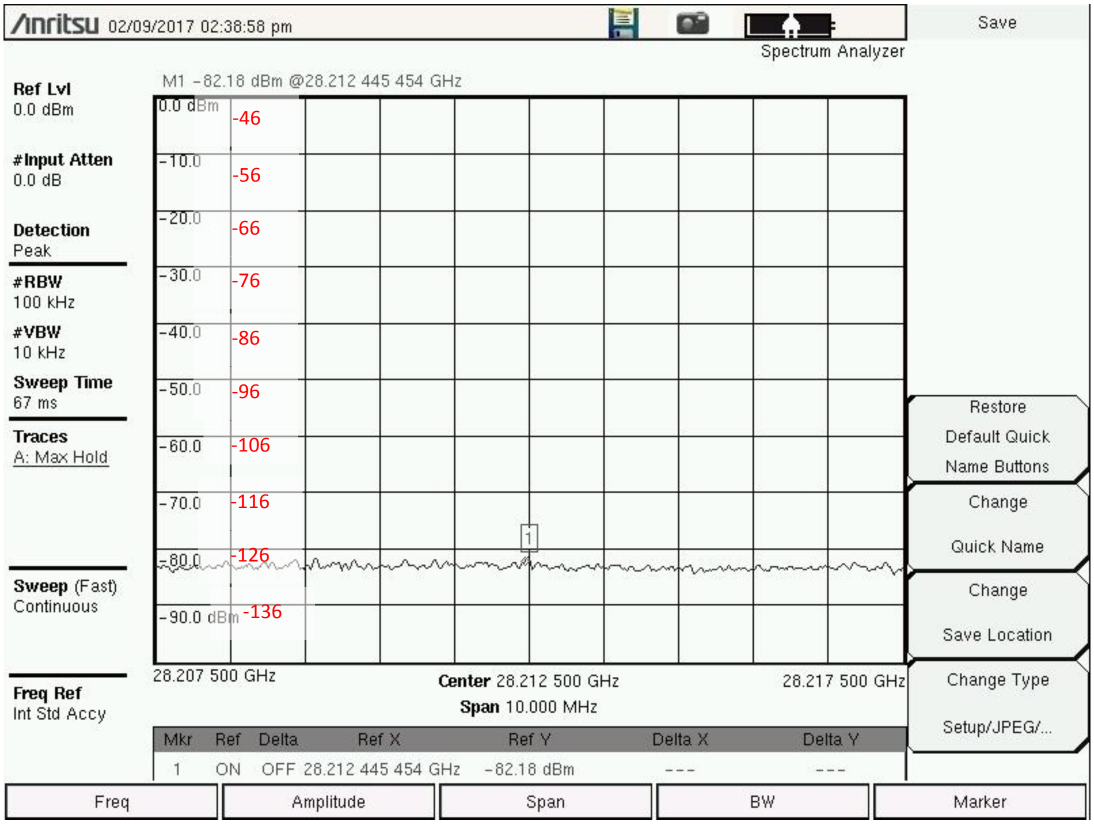


Figure 3.1-3 (Q) Spectrum Photos 28 GHz - 100 kHz Res BW Site 9 at 10m AGL

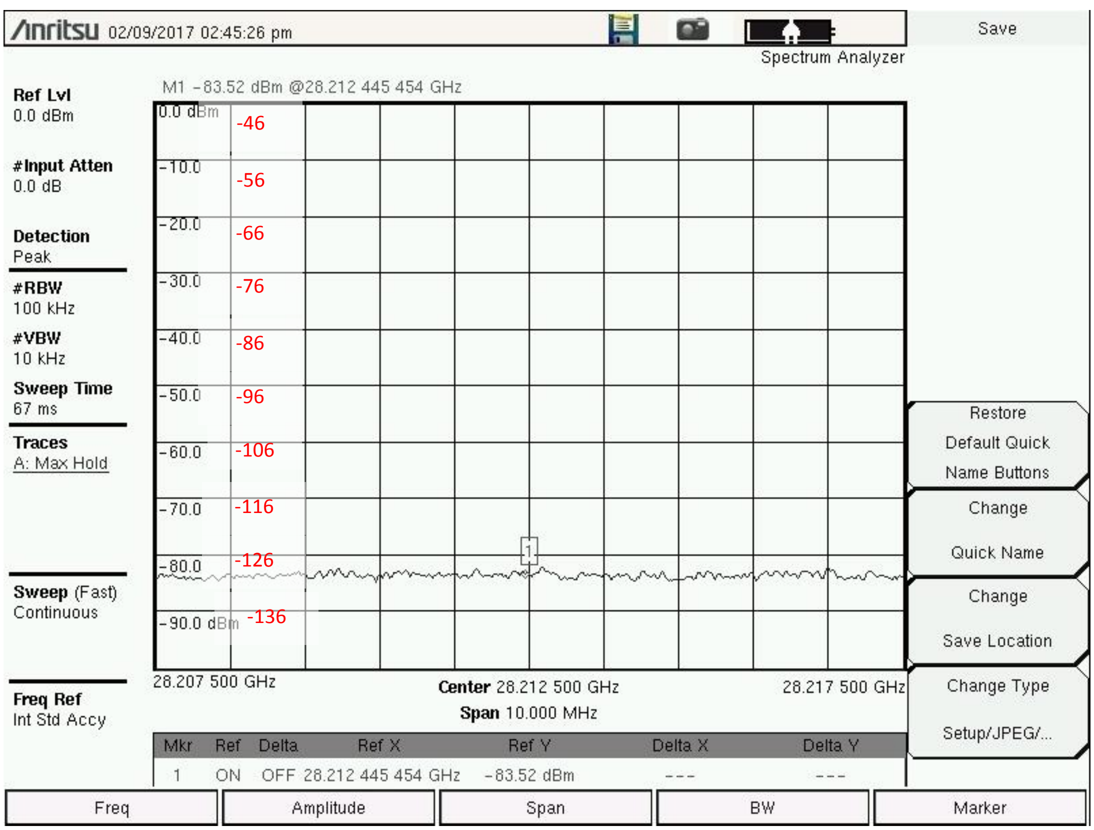


Figure 3.1-3 (R) Spectrum Photos 28 GHz - 100 kHz Res BW Site 9 at 2m AGL

Adjusted measurement values (dBm_I) shown in red

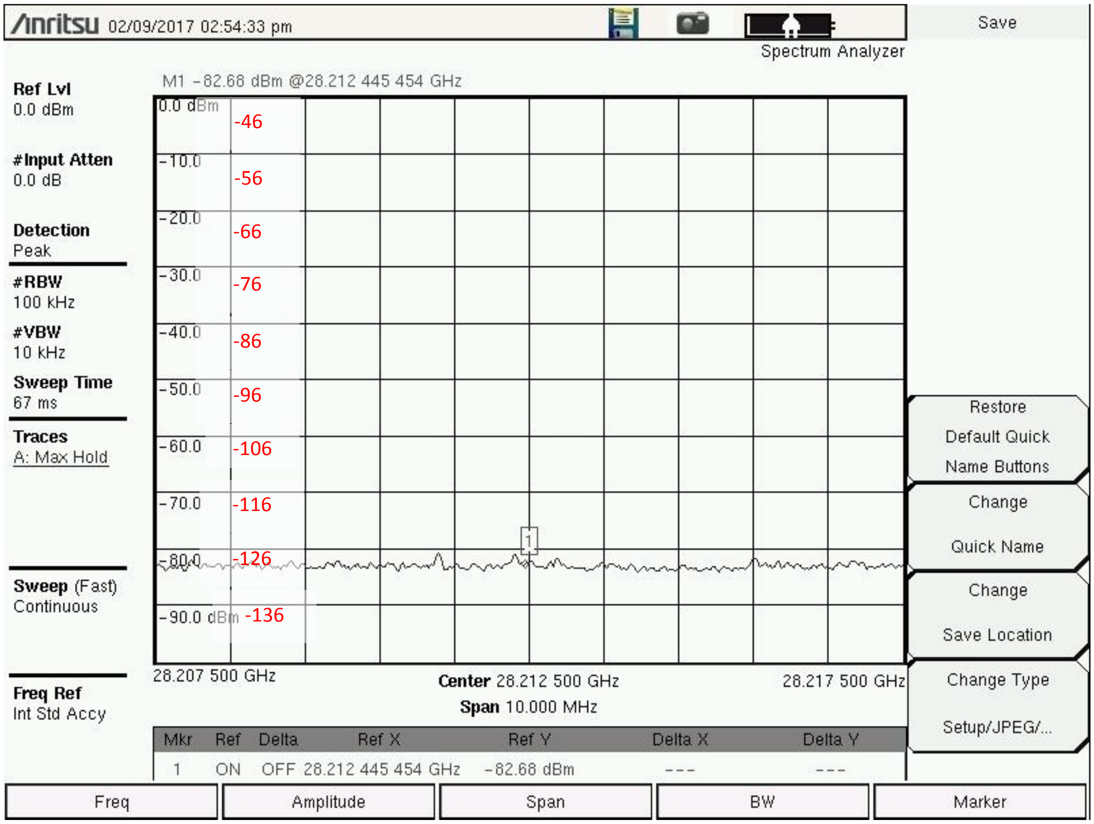


Figure 3.1-3 (S) Spectrum Photos 28 GHz - 100 kHz Res BW Site 10 at 10m AGL

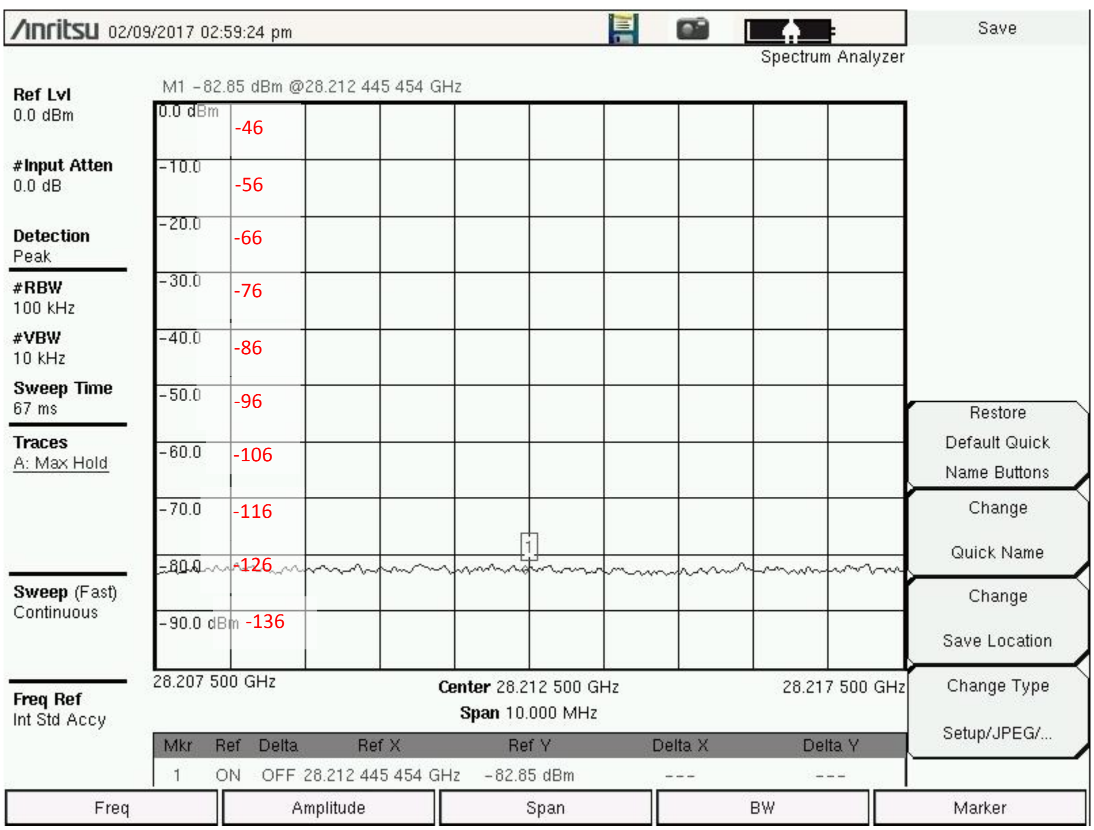


Figure 3.1-3 (T) Spectrum Photos 28 GHz - 100 kHz Res BW Site 10 at 2m AGL

Adjusted measurement values (dBm_I) shown in red

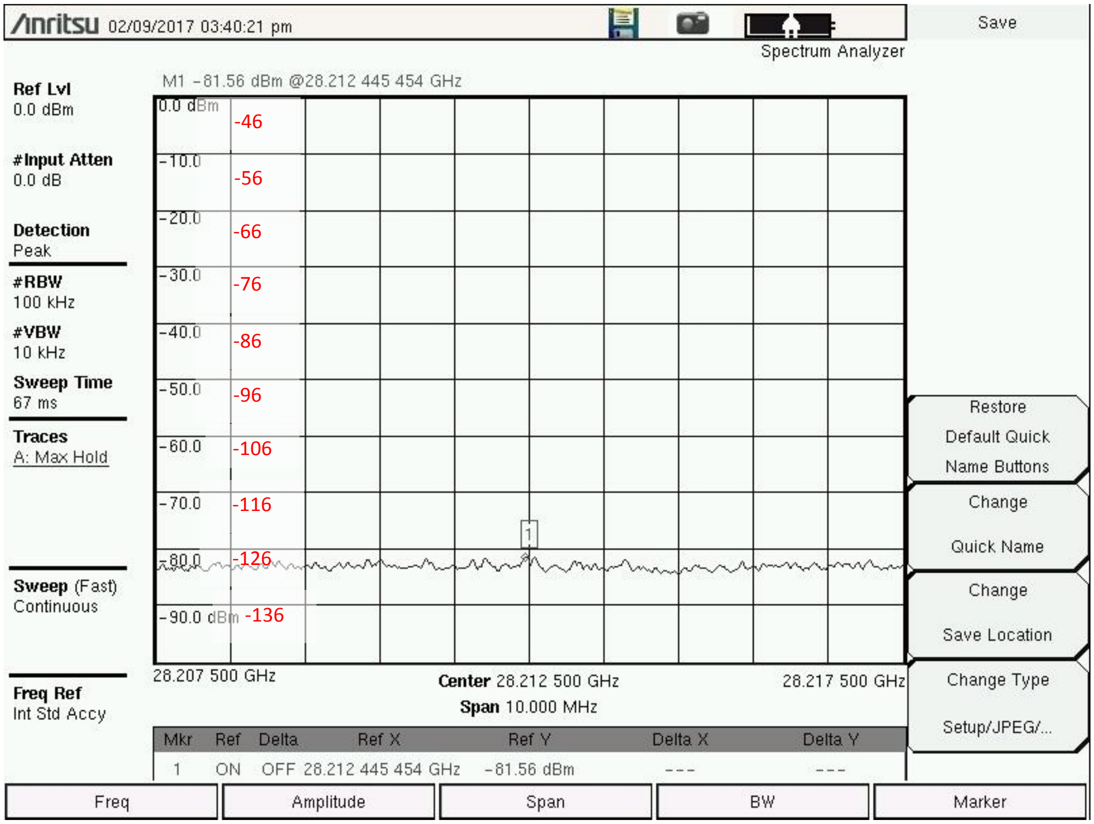


Figure 3.1-3 (U) Spectrum Photos 28 GHz - 100 kHz Res BW Site 11 at 10m AGL-82

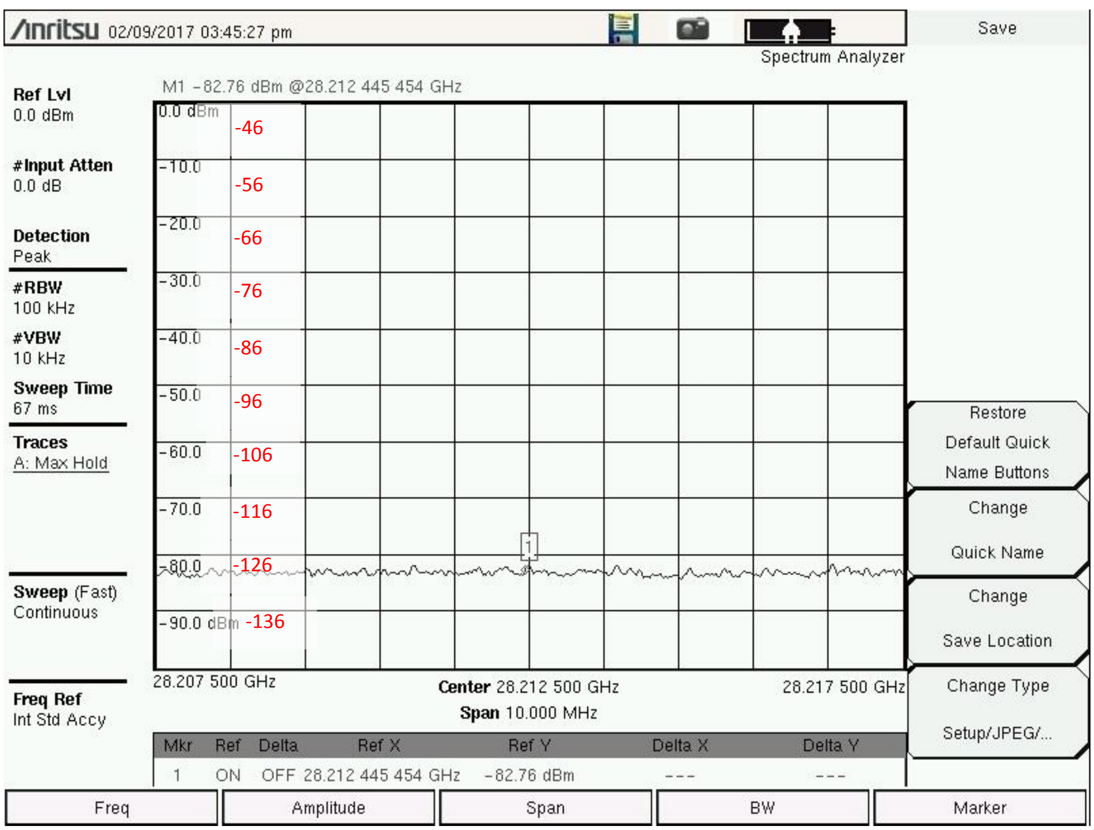


Figure 3.1-3 (V) Spectrum Photos 28 GHz - 100 kHz Res BW Site 11 at 2m AGL

Adjusted measurement values (dBm_I) shown in red

SECTION

FOUR

SECTION 4

SUMMARY OF RESULTS

The results of the measurements conducted at the ViaSat, Inc transmit site in Carlsbad, CA are presented in this section.

Ka-Band Measurements:

The tables on the next page contain the data collected during the RF Measurements on February 14, 2017.

Table 4.1
Data from RF Measurements at 10m Above Ground Level

Measurement Location	Latitude	Longitude	Azimuth From TX Antenna (°)	Azimuth to TX Antenna (°)	Test Antenna Height AGL (m)	Distance from TX Antenna (m)	Signal Value Recorded (dBm)	Signal Value Recorded (dBW)	Figure Number
Site 1	33.126722	-117.265194	170.29	350.29	10	66	-107.51	-137.51	3.1-3 (A)
Site 2	33.126778	-117.264917	147.79	327.79	10	69.5	-119.10	-149.10	3.1-3 (C)
Site 3	33.127194	-117.263972	95.76	275.76	10	126	-111.30	-141.30	3.1-3 (E)
Site 4	33.127583	-117.263194	81.23	261.23	10	200	-103.25	-133.25	3.1-3 (G)
Site 5	33.127222	-117.261917	91.72	271.73	10	317	-110.68	-140.68	3.1-3 (I)
Site 6	33.125778	-117.262028	118.97	298.97	10	350	-114.95	-144.95	3.1-3 (K)
Site 7	33.125611	-117.263000	131.08	311.08	10	286	-125.96 NF	-155.96 NF	3.1-3 (M)
Site 8	33.125444	-117.264028	149.86	329.86	10	239	-128.63 NF	-158.63 NF	3.1-3 (O)
Site 9	33.124667	-117.264583	166.9	346.9	10	301	-128.10 NF	-158.10 NF	3.1-3 (Q)
Site 10	33.124139	-117.264806	172.31	352.31	10	355	-128.60 NF	-158.60 NF	3.1-3 (S)
Site 11	33.127972	-117.265222	6.61	186.61	10	74.2	-127.48 NF	-157.48 NF	3.1-3 (U)

Table 4.2
Data from RF Measurements at 2m Above Ground Level

Measurement Location	Latitude	Longitude	Azimuth From TX Antenna (°)	Azimuth to TX Antenna (°)	Test Antenna Height AGL (m)	Distance from TX Antenna (m)	Signal Value Recorded (dBm)	Signal Value Recorded (dBW)	Figure Number
Site 1	33.126722	-117.265194	170.29	350.29	2	66	-128.19 NF	-158.19 NF	3.1-3 (B)
Site 2	33.126778	-117.264917	147.79	327.79	2	69.5	-125.56 NF	-155.56 NF	3.1-3 (D)
Site 3	33.127194	-117.263972	95.76	275.76	2	126	-129.65 NF	-159.65 NF	3.1-3 (F)
Site 4	33.127583	-117.263194	81.23	261.23	2	200	-130.00 NF	-160 NF	3.1-3 (H)
Site 5	33.127222	-117.261917	91.72	271.73	2	317	-117.78	-147.78	3.1-3 (J)
Site 6	33.125778	-117.262028	118.97	298.97	2	350	-124.82	-154.82	3.1-3 (L)
Site 7	33.125611	-117.263000	131.08	311.08	2	286	-128.19 NF	-158.19 NF	3.1-3 (N)
Site 8	33.125444	-117.264028	149.86	329.86	2	239	-128.63 NF	-158.63 NF	3.1-3 (P)
Site 9	33.124667	-117.264583	166.9	346.9	2	301	-129.44 NF	-159.44 NF	3.1-3 (R)
Site 10	33.124139	-117.264806	172.31	352.31	2	355	-128.77 NF	-158.77 NF	3.1-3 (T)
Site 11	33.127972	-117.265222	6.61	186.61	2	74.2	-128.78 NF	-158.78 NF	3.1-3 (V)

NF = Noise Floor of Test System

SECTION

FIVE

SECTION 5

CONCLUSIONS

5.1 Conclusions

Measureable signals above the measurement system's noise floor were observed at test sites 1 through 6 at 10 meters AGL. No measurable signals were observed above the measurement system's noise floor at sites 7 through 11 at 10 meters AGL.

Measureable signals above the measurement system's noise floor were observed at test sites 5 and 6 at 2 meters AGL. No measureable signals were observed above the measurement system's noise floor at all other sites at 2 meters AGL.

The highest observed signal was -103.25 dBm (-133.25 dBW) at site 4 at 10 meters AGL.

The values measured in this report are intended for use by ViaSat for incorporation into a larger analysis where ViaSat will perform the necessary calculations to convert the measured signals in dBm (dBW) to an equivalent power flux density in dBm/(m^2*MHz) and to determine, where possible, the effective signal attenuation over and above free space loss. As an element of a larger analysis, information in this report is not intended to be used on a standalone basis.